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THESIS

OFF-DESIGN LOSS MEASUREMENTS IN A COMPRESSOR CASCADE

by

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September 1989

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OFF-DESIGN LOSS MEASUREMENTS
IN A COMPRESSOR CASCADE

by

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Submitted in partial fulfillment
of the requirements for the degree of

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ABSTRACT

Data acquisition software was written to recover the ability to make loss measurements using a five-hole pneumatic probe in a wind tunnel facility currently containing a modeled subsonic cascade of controlled diffusion (CD) stator blades. Acquisition, reduction and ancillary programs were written for a Hewlett Packard 9000 Series 300 computer/HP 3052 Data Acquisition System in HP BASIC 5.0. The new software was demonstrated and validated by conducting a set of surveys at the (near to stall) air inlet flow angle of 48 degrees. The survey results showed a diminishing core of two-dimensional flow through the blading due to side wall boundary layer effects, and integration of upstream and downstream measurements gave an axial velocity-density ratio of 1.108 and a NASA loss coefficient of 0.097. Prior to the surveys, the probe was calibrated in a free jet facility, thus also revalidating the calibration software. It was concluded that the facility instrumentation and procedures were now in place for making accurate off-design loss measurements on a routine basis.

THESIS DISCLAIMER

The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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LIST OF SYMBOLS

English Letter Symbols

AVDR	Axial Velocity Density Ratio
C_P	Pressure coefficient
$\overline{C}_P$	Mass averaged coefficient of pressure from instrumented blade
C_{P_2}	Static pressure rise coefficient
c	Chord
c_p	Specific heat at a constant pressure
h	Span-wise depth of control volume
M	Mach number
n	Number of scans
P	Pressure
Q	Dynamic pressure ($1/2 \ \rho V^2$)
s	Blade spacing
T	Temperature
V	Velocity
X	Nondimensional velocity
x	Position of probe in blade-to-blade direction

Greek Letter Symbols

β	Flow angle
γ	Ratio of specific heats
ϖ	Loss coefficient
ρ	Density

Subscripts

1	Upstream survey station
2	Downstream survey station
a	Atmospheric
l	Local
p	Measured in the plenum
ref	Reference value derived from plenum stagnation pressure
s	Static
t	Stagnation or total

Superscripts

^	Ensemble average of values during a survey

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I. INTRODUCTION

Off-design compressor performance is becoming more important as future engine design goals involve higher thrust-to-weight ratios, lower specific fuel consumption, and smaller size. Currently, great demands on the engine are made during high angle-of-attack flight by fighter aircraft and by VSTOL and rotorcraft operating in flight conditions that greatly distort the flow to the compressor. Design goals and extreme operating conditions push the compressor operating point towards the stall boundary. Thus, it is vitally important to have methods for predicting stall margin in the process of design.

The modeling of compressor flows using computational fluid dynamic (CFD) codes is the key to such a development, and cascade data on flow structure and blade element behavior are required to validate the codes. While flow structure of the velocity field can be mapped using a laser dopler velocimeter (LDV) system, it is the loss coefficient (introduced in Chapter VI of Ref. 1) which is the essential integral measure of the blade element performance. The focus of the present work was to recover the ability to make loss measurements using a pressure probe in the Naval Postgraduate School's (NPS) cascade facility.

In the present study, the cascade was configured with the mid section of a controlled diffusion (CD) stator blade designed by Sanger [Ref. 2] at NASA Lewis Research Center.

Previous studies using CD blading in this facility include the work of Koyuncu [Ref. 3], who conducted fourteen tests at air inlet angles from 24.3 degrees to 47.2 degrees to measure blade performance using pressure probes. Dreon [Ref. 4] followed with probe studies at air inlet angles of 40.3 degrees and 43.4 degrees, concentrating on verifying the accuracy of the loss measurements. Dreon's work is cited frequently throughout the present report since much of what he did, in principle, was used to guide the present work. Elazar [Ref. 5] performed detailed measurements of inviscid flow in the passage between two adjacent blades, the boundary layer development on the blade surfaces and the early wake development using a two-component LDV system. Baydar [Ref. 6] made wake measurements using hot wires to verify the LDV wake measurements made by Elazar. In these earlier studies, the cascade flow was found to be acceptably uniform and periodic (each blade passage the same), and showed good span-wise independence. Cascade flow quality was initially analyzed by NACA [Ref. 7] and first addressed at NPS by Duval [Ref. 8].

The necessity for the present work arose when an obsolete and unsupported computer was replaced by a Hewlett Packard 300 PC in an upgrade of the facility's data acquisition system. Entirely new software was required to be written (using HP BASIC 5.0) to replace the many previous programs. A simple translation of the previous software was not attempted in view of the undocumented

modifications generated by a series of previous investigators. The new software is described fully in Appendix B.

Overall, recovering the ability to make loss measurements involved first, the calibration of a five-hole conical pressure probe (Appendix A), second, developing the required acquisition and reduction software and third, obtaining a complete set of preliminary measurements at an air inlet angle of 48 degrees to demonstrate and validate all aspects of the procedure. The conclusion of the study was that the calibrated probe and data acquisition system are indeed operational, and ready to be used to make surveys and loss measurements in the cascade.

Section II of this report describes the experimental apparatus, namely the cascade facility, instrumentation and the data system. Section III addresses the test conditions, calibration, procedures, method of referencing, and outlines the measurements that were made. The results are presented and discussed in Section IV followed by conclusions and recommendations in Section V. Appendix A contains the details of the probe calibration. Appendix B contains a complete discription of the new software, with listings of all programs and samples of the printed output tables. Appendix B is intended to serve as a description and user guide to the software. Finally, Appendix C outlines procedures for referencing the probe yaw angle.

II. EXPERIMENTAL APPARATUS

A. CASCADE WIND TUNNEL

The NPGS cascade facility is shown in Fig. 1. Figure 2 shows the test section. A detailed description of the facility, test section and CD blading is contained in Ref. 9.

B. CONTROLLED DIFFUSION BLADING

Reference 2 describes the CD blading in detail. A profile of blade and pressure tap locations on instrumented blades are shown in Fig. 3.

C. INSTRUMENTATION

The five-hole conical probe used and described by Dreon [Ref. 4] was calibrated and used for the probe measurements. Appendix A contains the calibration details.

The iron-constantan thermocouple, plenum pressure probe and instrumented CD blade were used as described by Dreon. Wall static pressure was measured from a centrally located tap upstream of the blades. A Prandtl probe was installed approximately midway between the inlet guide vanes and the test blading. The probe was located at mid span between blades 15 and 16, well clear of the probe survey locations. The Prandtl probe measurements provided an additional measure of tunnel conditions. The cone probe, plenum, wall static and Prandtl probe pressures were connected to a 48-port Scanivalve. A second Scanivalve sampled pressures

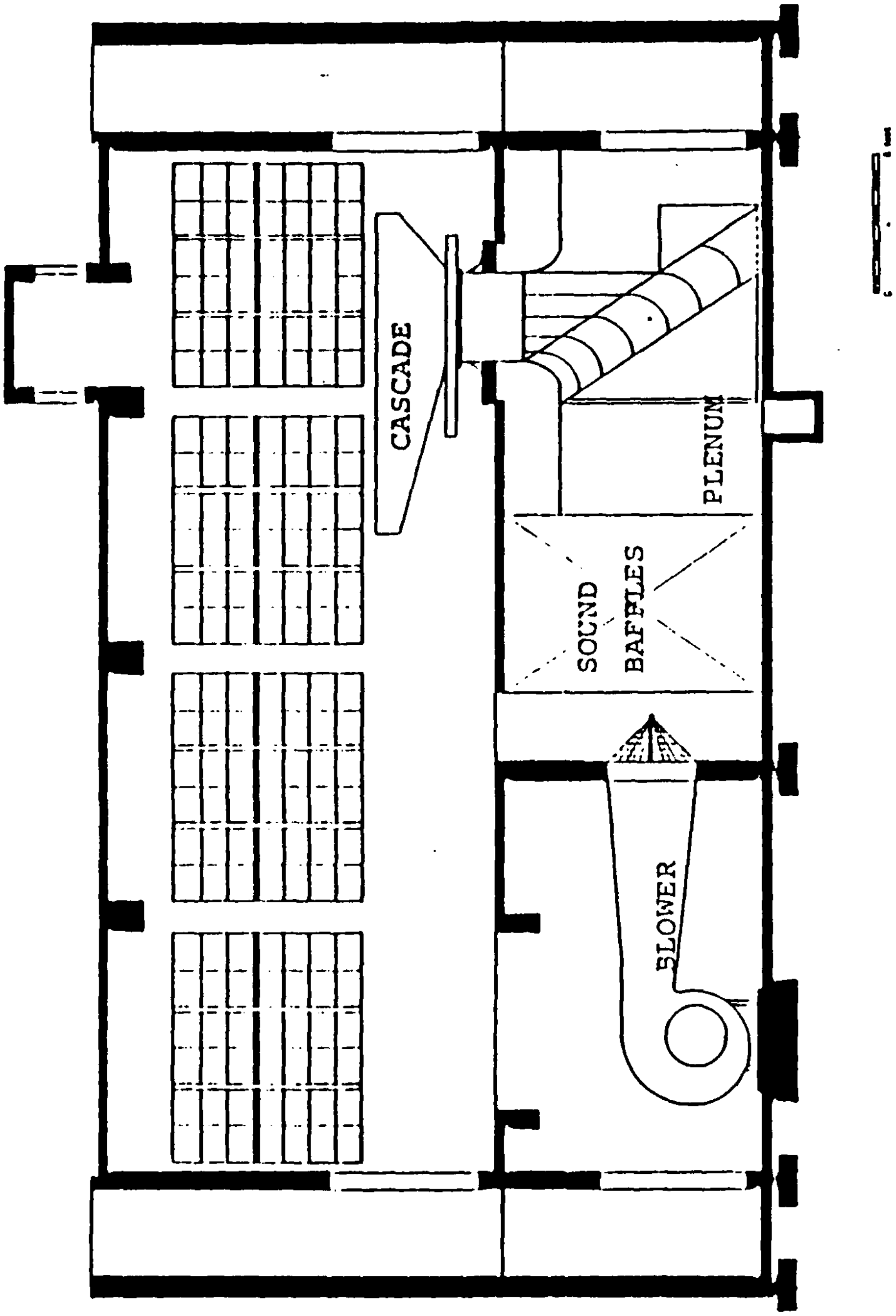


Figure 1. Cascade Wind Tunnel Test Facility

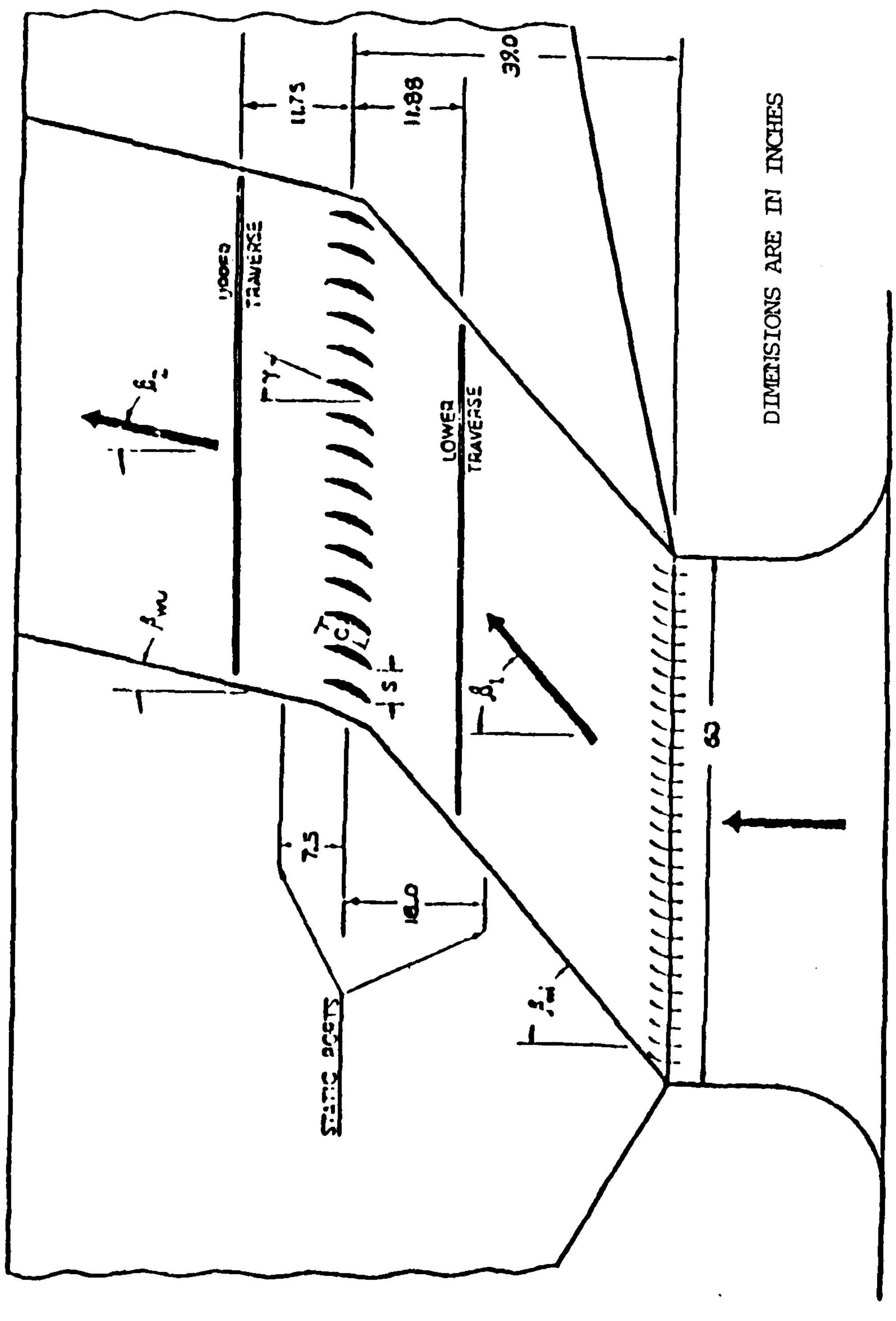


Figure 2. Cascade Test Section Schematic

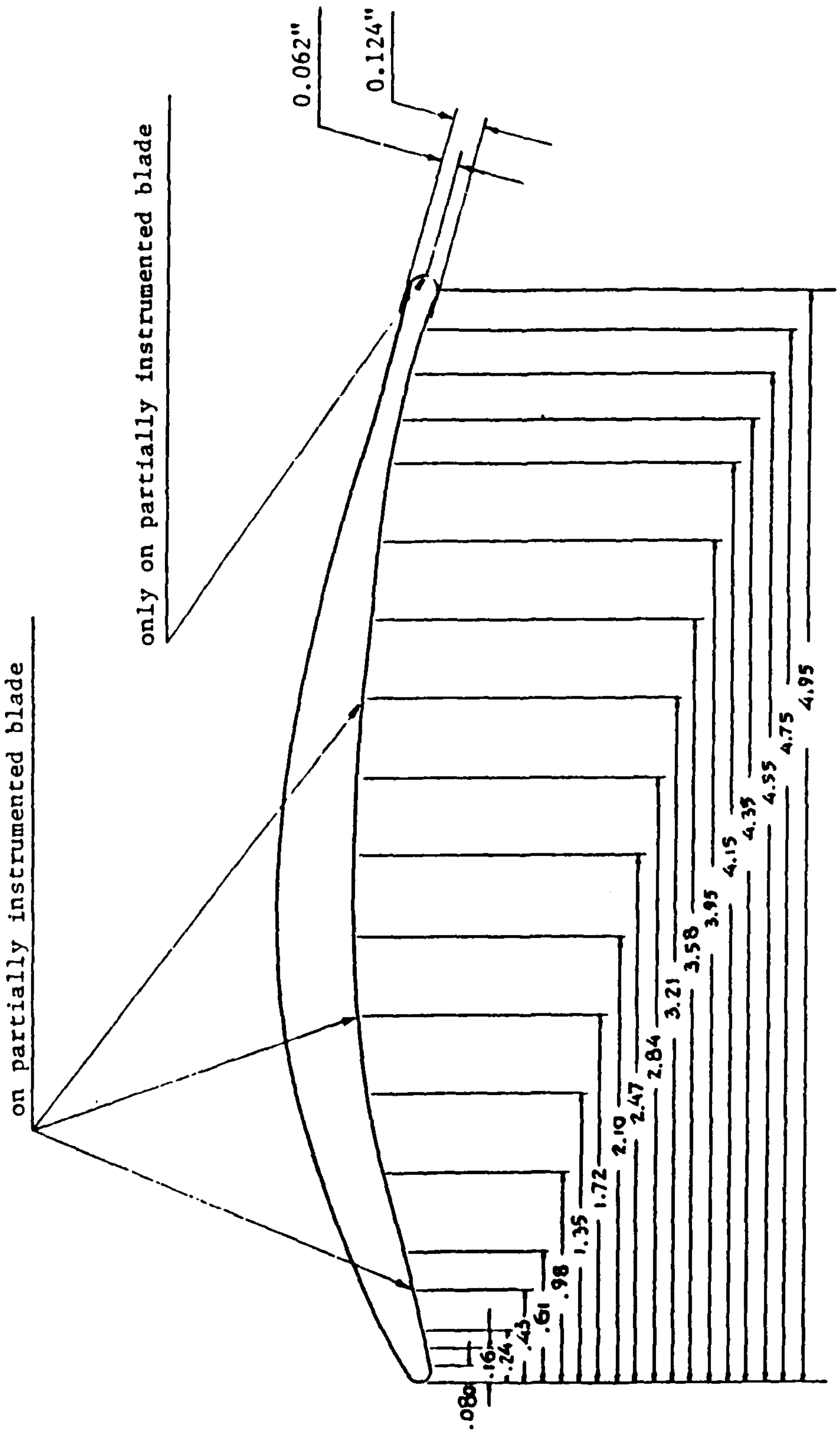


Figure 3. CD Blade Pressure Tap Locations

from the fully (blade 10) and one partially instrumented blade (blade 11), and from the plenum.

A yaw transducer on the conical probe, linear over the range used, provided the means to record inlet and outlet flow angles.

Probe displacement in the blade-to-blade direction was determined by a turn counter on the motor-driven traverse mechanism.

Span-wise displacement was recorded manually from a vernier scale attached to the probe.

D. DATA ACQUISITION SYSTEM

1. Hardware

A simplified schematic of the data acquisition system is shown in Fig. 4.

The data were collected using the Hewlett Packard Data Acquisition System (HP-3052) with instruments connected through an Interface Bus (HP-98034, HP-IB). The HG-78K Scanivalve controller, which controlled the selection and positioning of the Scanivalves is described by Geopfarth [Ref. 10]. A Hewlett Packard 900 series 300 computer controlled the system. The instrumentation channel assignments are given in Table B1.

2. Software

Three programs comprise the data acquisition software. Program "ACQUIRE" controls the acquisition and stores the collected data. Program "CALC" reduces the data to commonly used engineering quantities and "LOSS" computes

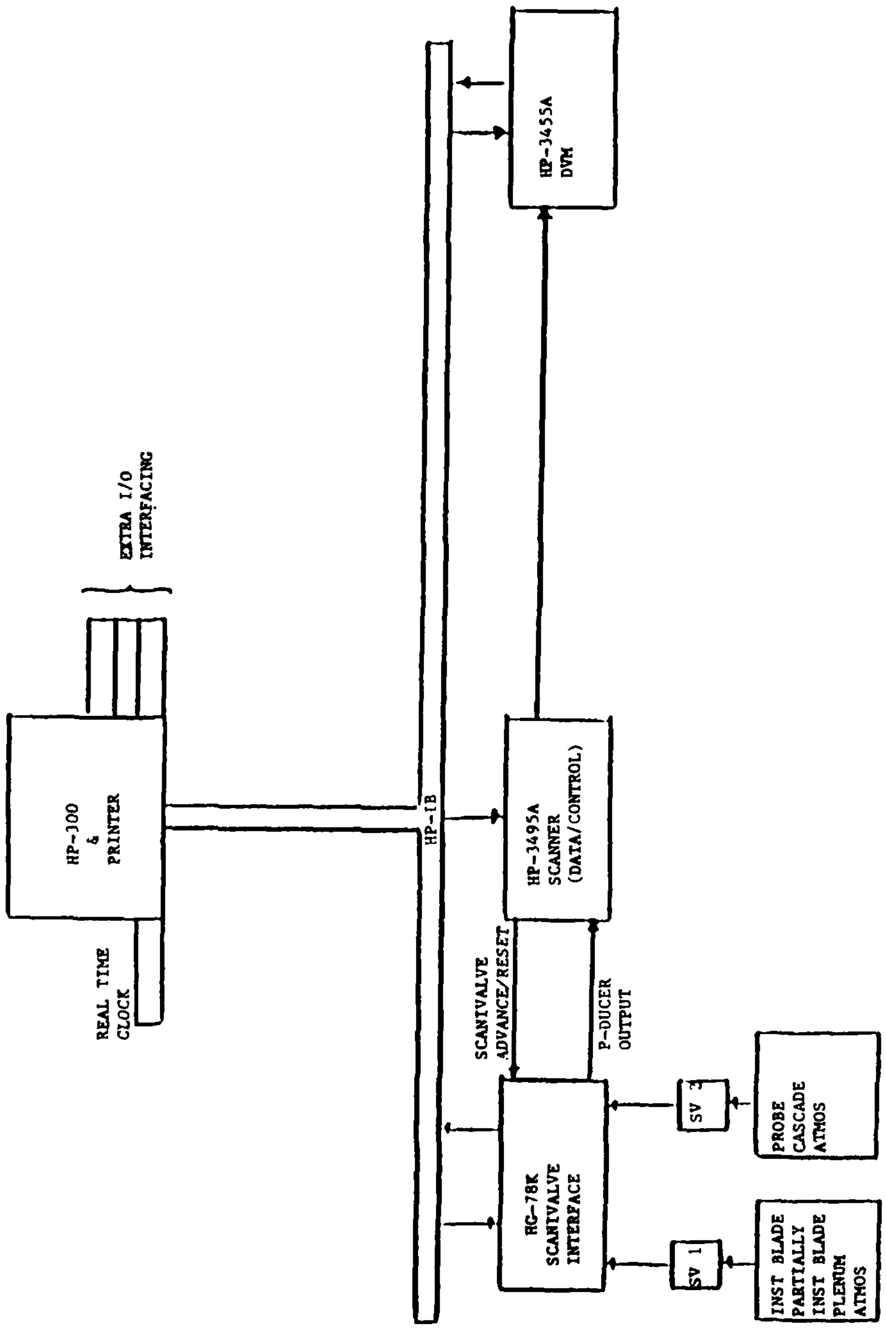


Figure 4. Data Acquisition System Block Diagram

the static pressure rise coefficient, axial velocity density ratio (AVDR) and loss coefficient. Software details are contained in Appendix B.

III. TEST PROCEDURES AND PROGRAM OF MEASUREMENTS

A. TEST PROCEDURES

1. Setting Test Conditions

Murray [Ref. 11], in a recently completed study, set the wall angle to 48 degrees for LDV measurements. A complete account of the angle setting procedure is given in Appendix A, Section VI of Ref. 11. All tests in the present study were conducted at a wall angle setting of 48 degrees and an inlet dynamic pressure (Q) of 17" H_2O. Atmospheric pressure was taken to be constant over the survey period of approximately two hours.

2. Calibration

The Scanivalves were calibrated prior to each test using shop air and a water manometer. The probe yaw transducer was scaled at two limiting settings prior to each test, having been shown previously to be linear to within 0.2 degrees—the resolution of the yaw vernier scale on the probe.

3. Referencing

Pressure and velocity values obtained by reducing probe test data at each probe position were referenced to the tunnel conditions at the time of the recording. This eliminated the effects that small changes in the tunnel supply conditions might have had on the calculation of the loss coefficient.

4. Data Points

The probe surveys consisted of a series of individual measurements at intervals ranging from .05 - .5 inches. At each interval, the probe was balanced in yaw (Appendix A) and measurements taken—defining a data point. The data collected were reduced using the equations given in Table I.

B. PROGRAM OF MEASUREMENTS

A summary of the probe surveys conducted in the present study is contained in Table II. First, a set of probe surveys was conducted to establish the flow quality into the cascade test section. Second, an inlet survey in the blade-to-blade direction was conducted to examine inlet uniformity. Span-wise surveys upstream and downstream of the blades were then made to examine two-dimensionality. Finally, detailed blade-to-blade, mid-span surveys over one blade passage were made upstream and downstream in order to compute the loss coefficient.

Upstream and downstream surveys were made at the traverse locations indicated in Fig. 2. Intervals between data points were decreased when a change in flow conditions was evident. Downstream span-wise surveys were located $\pm$ 1.2 inches from a vertical extension of the trailing edge of blade 9. Surface tap pressures were recorded from the instrumented blade after the last probe data point was recorded for the upstream blade-to-blade survey. Additionally, pressures were recorded from the partially

TABLE I. DATA REDUCTION FORMULAE

PARAMETER	EXPRESSION	PROGRAMMED EXPRESSION
X	$\left[\dfrac{\frac{\gamma-1}{2} M^2}{1+\frac{\gamma-1}{2} M^2}\right]^{\frac{1}{2}}$	same
P_s	$P_t\,(1-X^2)^{\frac{\gamma}{\gamma-1}}$	same
V	$X\,[2\,c_p T_p]^{\frac{1}{2}}$	$X\,[2\,c_p (778)(32.174)\,T_p]^{\frac{1}{2}}$
Q	$P_t\left(\frac{\gamma}{\gamma-1}\right) X^2\,(1-X^2)^{\frac{1}{\gamma-1}}$	same
$\hat{P}_p$	$\frac{1}{n}\sum_{n=1}^{n} P_p$	same
$\hat{T}_p$	$\frac{1}{n}\sum_{n=1}^{n} T_p$	same
X_{ref}	$\left[1-\left(\frac{P_s}{P_p}\right)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{1}{2}}$	same
V_{ref}	$X_{ref}\,[2\,c_p T_p]^{\frac{1}{2}}$	$X_{ref}\,[2\,c_p (778)(32.174)\,T_p]^{\frac{1}{2}}$
Q_{ref}	$P_p\left(\frac{\gamma}{\gamma-1}\right) X_{ref}^2\,(1-X_{ref}^2)^{\frac{1}{\gamma-1}}$	same
$\hat{X}_{ref}$	$\left[1-\left(\frac{P_s}{\hat{P}_p}\right)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{1}{2}}$	same
$\hat{V}_{ref}$	$\hat{X}_{ref}\,[2\,c_p \hat{T}_p]^{\frac{1}{2}}$	$\hat{X}_{ref}\,[2\,c_p (778)(32.179)\,\hat{T}_p]^{\frac{1}{2}}$

TABLE I. DATA REDUCTION FORMULAE (CONT.)

PARAMETER	EXPRESSION	PROGRAMMED EXPRESSION
$\hat{Q}_{ref}$	$\hat{P}_p\left(\frac{\gamma}{\gamma\text{-}1}\right)\hat{X}_{ref}^2(1\text{-}\hat{X}_{ref}^2)^{\frac{1}{\gamma\text{-}1}}$	same
* K		$\frac{P_t}{P_p}\ \frac{X}{X_{ref}}\left[\frac{1\text{-}X^2}{1\text{-}X_{ref}^2}\right]^{\frac{1}{\gamma\text{-}1}}\cos\beta$
* AVDR	$\frac{h_1}{h_2}$	$\dfrac{\int_0^s K_2\,dx}{\int_0^s K_1\,dx}$
C_{P_t}	$\frac{P_t}{P_p}$	same
C_{P_s}	$\frac{P_s}{P_p}$	same
* ϖ	$\dfrac{(\bar{C}_{P_{t_1}} - \bar{C}_{P_{t_2}})}{(\bar{C}_{P_{t_1}} - \bar{C}_{P_{s_1}})}$	$\dfrac{\int_0^s C_{P_{t_1}} K_1\,dx - \frac{1}{AVDR}\int_0^s C_{P_{t_2}} K_2\,dx}{\int_0^s C_{P_{t_1}} K_1\,dx - \int_0^s C_{P_{s_1}} K_1\,dx}$
$\overline{C_P}$	$\left[\frac{P_t - P_s}{P_p - P_s}\right]\left(\overline{\frac{P_p - P_s}{Q}}\right) + \left(\overline{\frac{P_s - P_e}{Q}}\right)$	$\left(\frac{P_t - P_s}{P_p - P_s}\right)\dfrac{\int_0^s \frac{P_p - P_s}{Q} K_1\,dx}{\int_0^s K_1\,dx} + \dfrac{\int_0^s \frac{P_s - P_e}{Q} K_1\,dx}{\int_0^s K_1\,dx}$
C_{P_2}	$\left(\overline{\frac{P_{s_2} - P_s}{Q}}\right) + \left(\overline{\frac{P_s - P_{s_1}}{Q}}\right)$	$\dfrac{\int_0^s \frac{P_{s_2} - P_s}{Q} K_1\,dx}{\int_0^s K_1\,dx} + \dfrac{\int_0^s \frac{P_s - P_{s_1}}{Q} K_1\,dx}{\int_0^s K_1\,dx}$

* Derivation given in Ref. 8

TABLE II - PROBE SURVEYS

SURVEY #	LOCATION	DIRECTION (Length)	NOMINAL INTERVAL(in.)
1	UPSTREAM	BLADE-TO-BLADE (20 Blade Spaces)	.5
2	UPSTREAM	SPAN-WISE	.05 - .1
3	DOWNSTREAM (Pressure Side, 1.2")	SPAN-WISE	.05 - .1
4	DOWNSTREAM (Suction Side, 1.2")	SPAN-WISE	.05 - .1
5	UPSTREAM	BLADE-TO-BLADE (1 Blade Space)	.1
6	DOWNSTREAM	BLADE-TO-BLADE (1 Blade Space)	.05 - .1

instrumented blade to aid in establishing periodicity. Three data points were collected from the suction side and two from the pressure side. Further, a trailing edge tap on this blade provided base pressure.

IV. RESULTS AND DISCUSSION

A. FLOW FIELD

The probe surveys were considered to be preliminary and were conducted primarily to demonstrate and validate the new data acquisition software. The results were interesting, however, since they were the first to be obtained at an inlet angle of 48 degrees with the CD blading. Survey results are presented in Figs. 5-22 and tabulations of the detailed blade-to-blade and instrumented blade data are given in Appendix B, Tables B2 - B7.

1. Inlet Flow Field

The inlet flow field was seen to be acceptably uniform. Deviations from a fully uniform velocity were due to inlet guide vane wakes and non-uniformity in vane geometry. A non-uniform migration of the guide vane wakes is thought to explain the irregular profile of the inlet flow angle across the span, seen in Fig. 10.

2. Two-Dimensionality and Periodicity

Downstream span-wise surveys, located one inch to both the pressure and suction sides of the blade, show a diminishing core of two-dimensional flow. This was the result of side-wall boundary layer build-up through the test section. Flow properties were independent of span only over a limited displacement to the pressure side of the blade. The significant difference between the pressure

and suction side span-wise profiles was due, in part, to the probe being in the blade wake on the suction side.

Periodicity cannot be shown with results obtained over only one blade passage. However, the first and last points in the downstream survey over one blade passage in Fig. 20 can be seen to be in good agreement, which is required if the flow is truly periodic over successive passages. The degree to which periodicity was manifested was also seen in Fig. 23. Three values of the coefficient of pressure for the partially instrumented blade are shown plotted with the distribution of values for the fully instrumented blade. Values for two other taps, towards the leading and trailing edge on the suction surface, were omitted due to partial blockage of the pneumatic lines leading from these taps to the Scanivalve; otherwise, good agreement was noted.

B. BLADE ELEMENT PERFORMANCE

In the distribution of pressure shown in Fig. 23, a strong adverse pressure gradient is clearly indicated over the first ten percent of the blade chord on the suction side. The profile was similar in shape to those recorded in Dreon's [Ref. 4] and Elazar's [Ref. 5] work at inlet angles of 43.7 degrees and 46 degrees respectively. It is noted that the trailing edge (base) pressure on the partially instrumented blade gave $C_p = 0.253$.

From an integration of the data obtained in surveys 5 and 6 (Table II) using program "LOSS" (Appendix B), the AVDR was calculated to be 1.108 and the loss coefficient

was 0.097. The loss coefficient value is shown plotted in Fig. 24 where it can be seen in relation to Dreon's and Koyuncu's [Ref. 3] losses.

C. MEASUREMENT UNCERTAINTIES

All measurement uncertainties listed in Table I of Ref. 4 were the same for the present study except those for the inlet and outlet flow angles. The absolute values of the flow angle for the present data were not known to better than an uncertainty $\pm$ 2 degrees. The means to establish a pneumatic axis referenced to a precisely measured horizontal or vertical axis on the cascade was not available at the time of the measurements. The probe yaw angle readout was set to zero when the probe tip was judged to be pointing vertically downward. The inlet angle was subsequently observed to indicate approximately 48 degrees at the inlet station, consistent with Murray's [Ref. 11] observations. The yaw angles recorded during the tests were uncertain on an absolute basis; however, the relative flow angles recorded from the yaw transducer during the surveys were accurate to within 0.2 degrees.

The proposed method for obtaining absolute accuracy in the yaw angle measurements, using the optical accuracy of the LDV system for referencing, is given in Appendix C.

D. TABULATED AND PLOTTED QUANTITIES

The data from surveys 5 and 6 (Table II) are shown in Tables B2 - B5. The tables include values of the

Scanivalve gauge pressures, yaw transducer reading, plenum temperature (total temperature) and atmospheric pressure. Pressures are given in inches of water. Table B1 will aid in interpreting the scaled probe data.

Appendix B defines and describes the quantities Beta, Gamma and Phi which are listed in Tables B3 and B5. The ensemble averages given at the end of Tables B3 and B5 represent the nominal (ensemble averaged) test conditions for the survey. All other quantities can be interpreted using the List of Symbols and Table I.

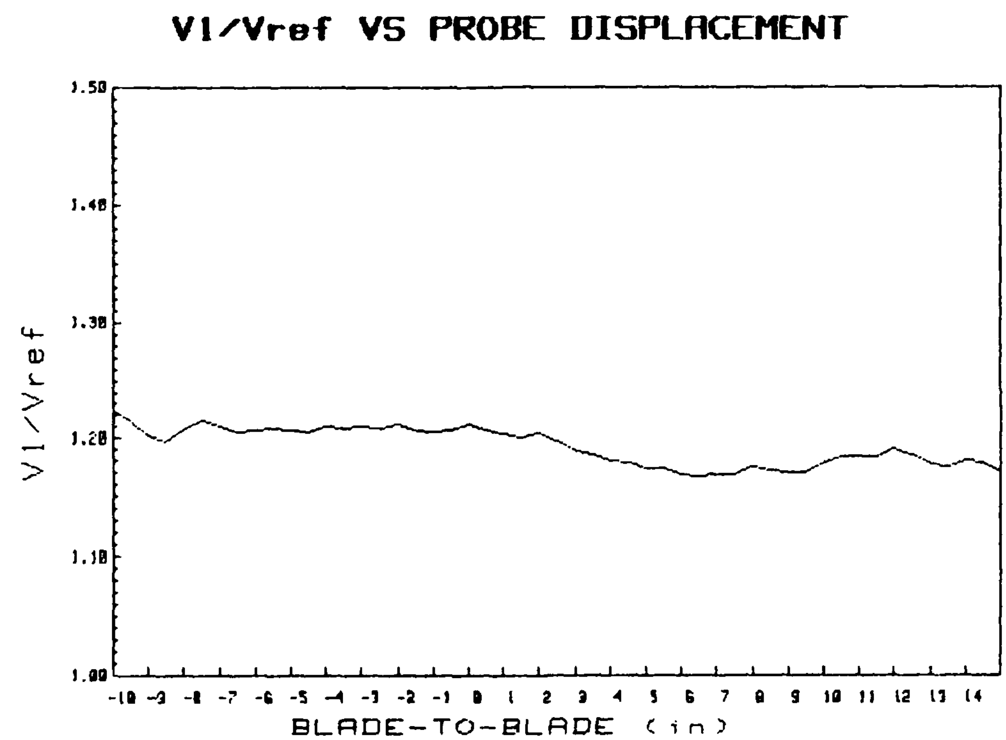


Figure 5. Inlet Survey: V1/Vref vs. Probe Displacement, Blade-to-Blade

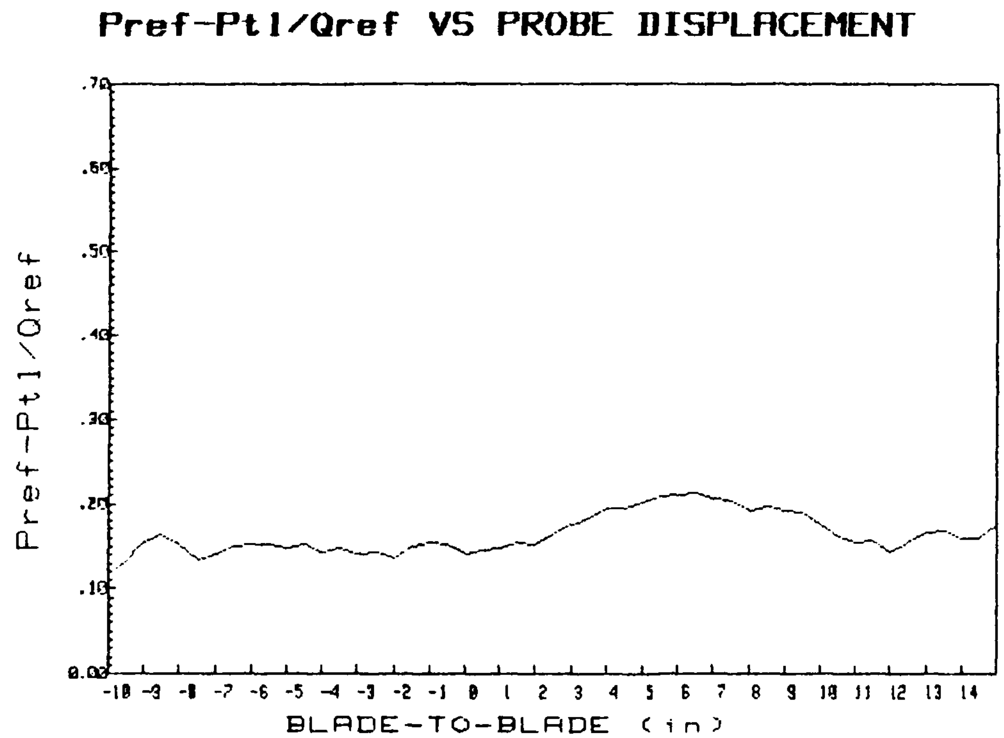


Figure 6. Inlet Survey: Pref-Ptl/Qref vs. Probe Displacement, Blade-to-Blade

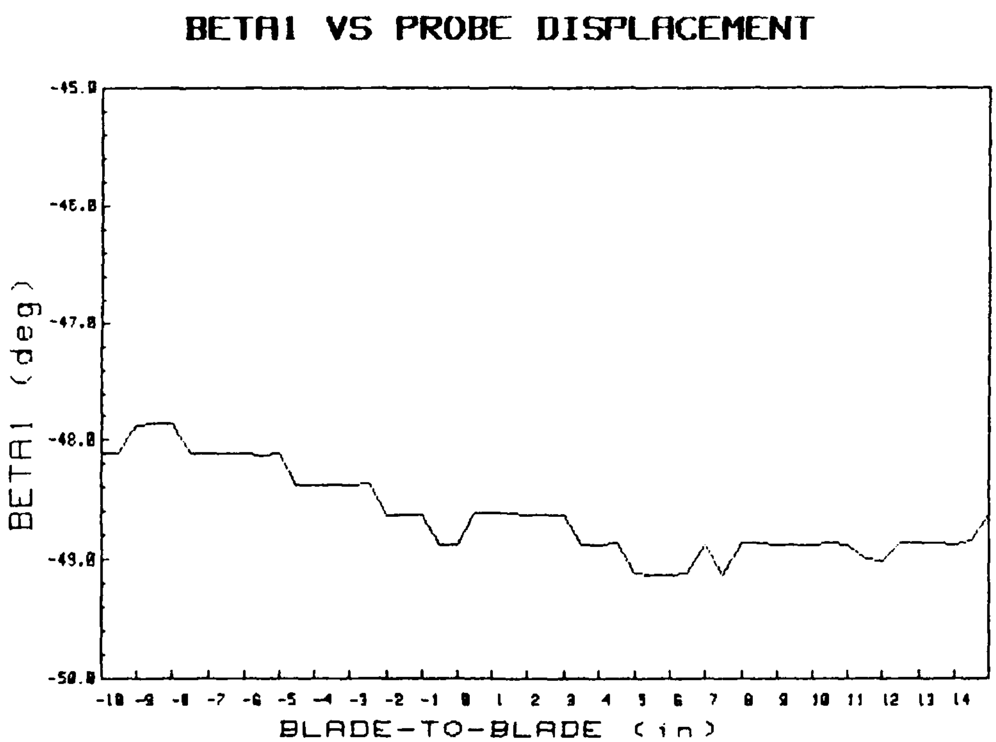


Figure 7. Inlet Survey: Betal vs. Probe Displacement, Blade-to-Blade

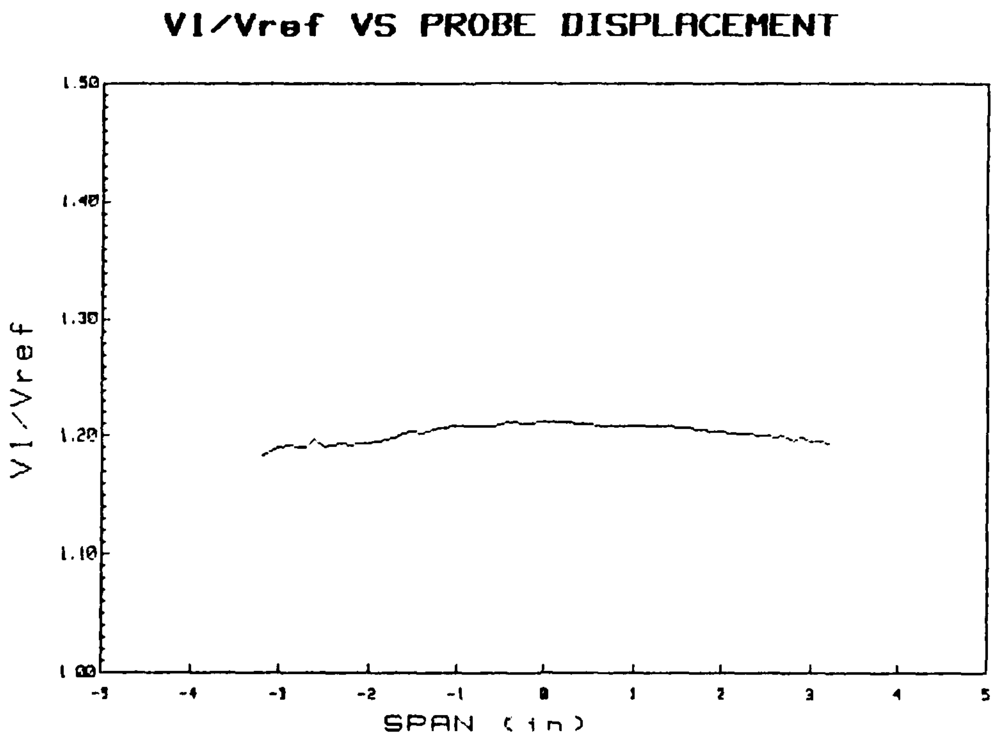


Figure 8. Inlet Survey: V1/Vref vs. Probe Displacement, Spanwise

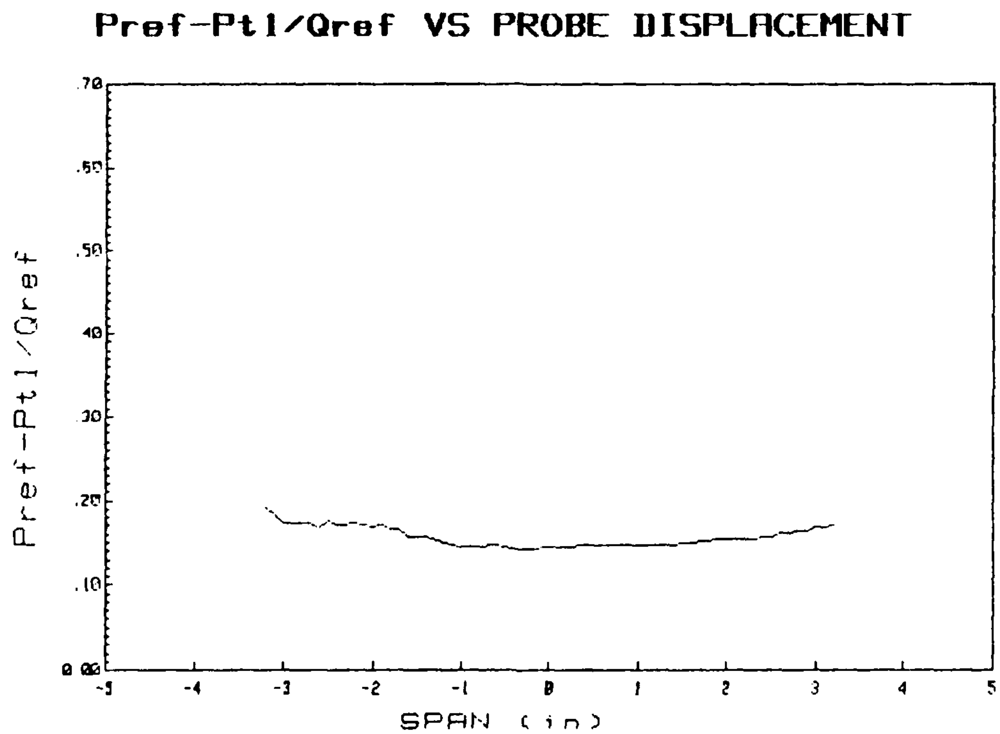


Figure 9. Inlet Survey: Pref-Pt1/Qref vs.
Probe Displacement, Spanwise

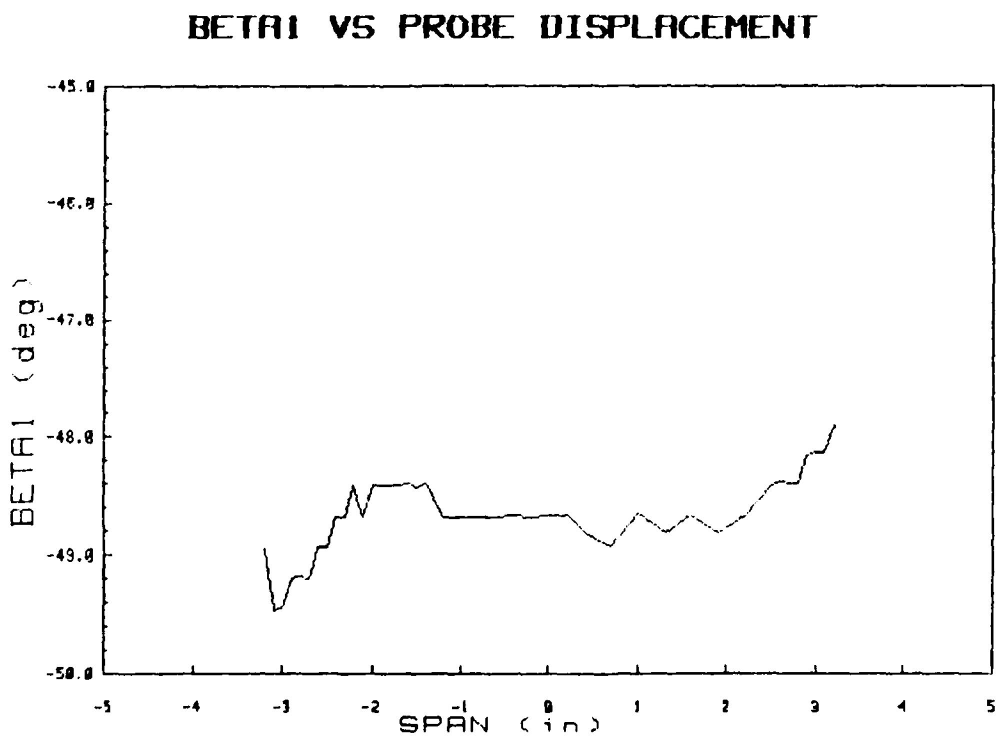


Figure 10. Inlet Survey: Beta1 vs. Probe Displacement, Spanwise

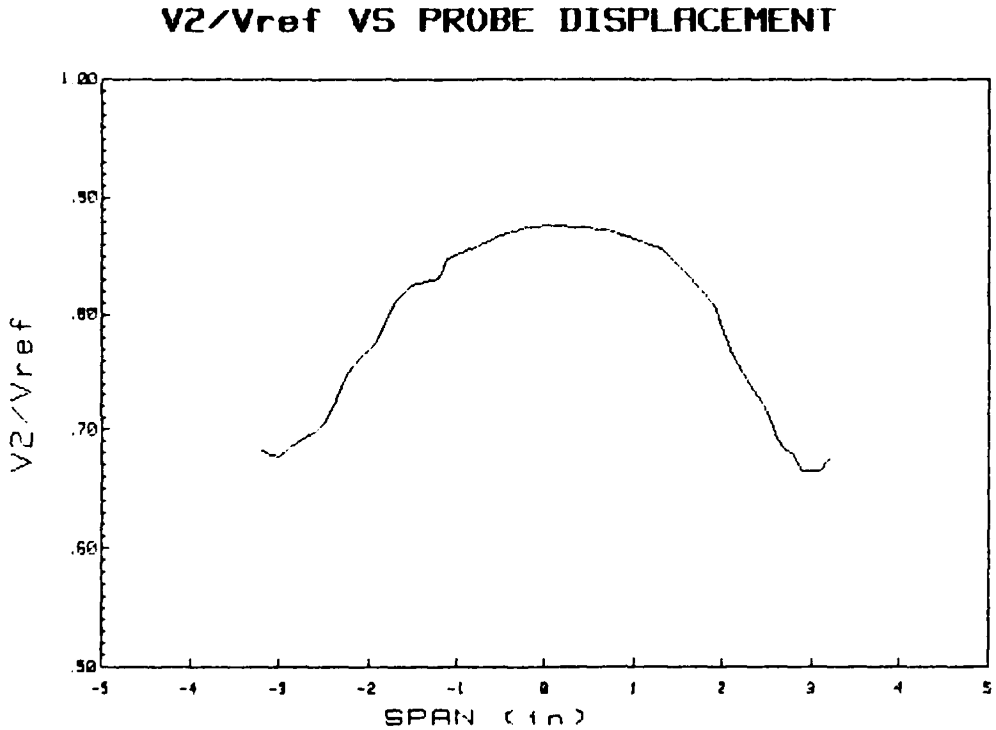


Figure 11. Outlet Survey: V2/Vref vs. Probe Displacement, Spanwise (Pressure Side)

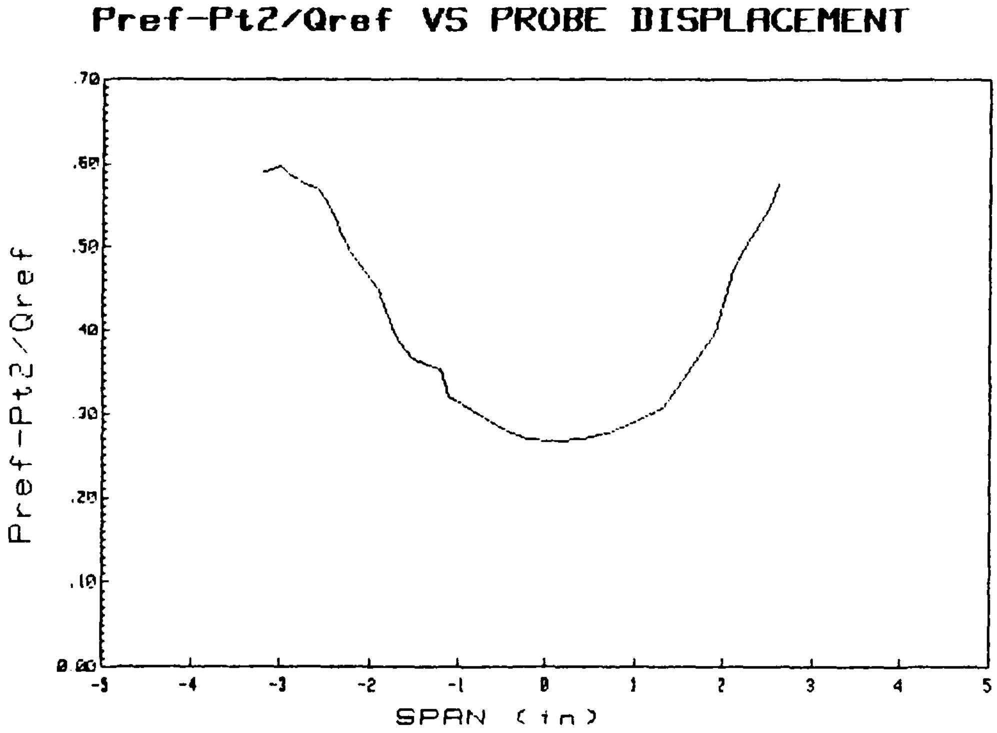


Figure 12. Outlet Survey: Pref-Pt2/Qref vs. Probe Displacement, Spanwise (Pressure Side)

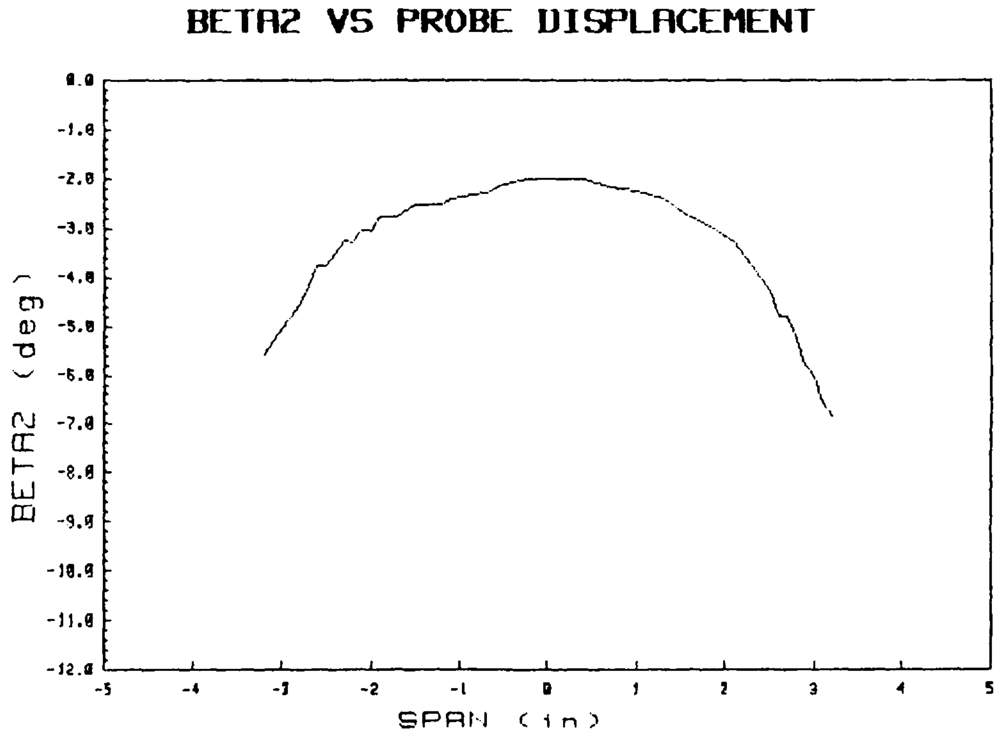


Figure 13. Outlet Survey: Beta2 vs. Probe Displacement, Spanwise (Pressure Side)

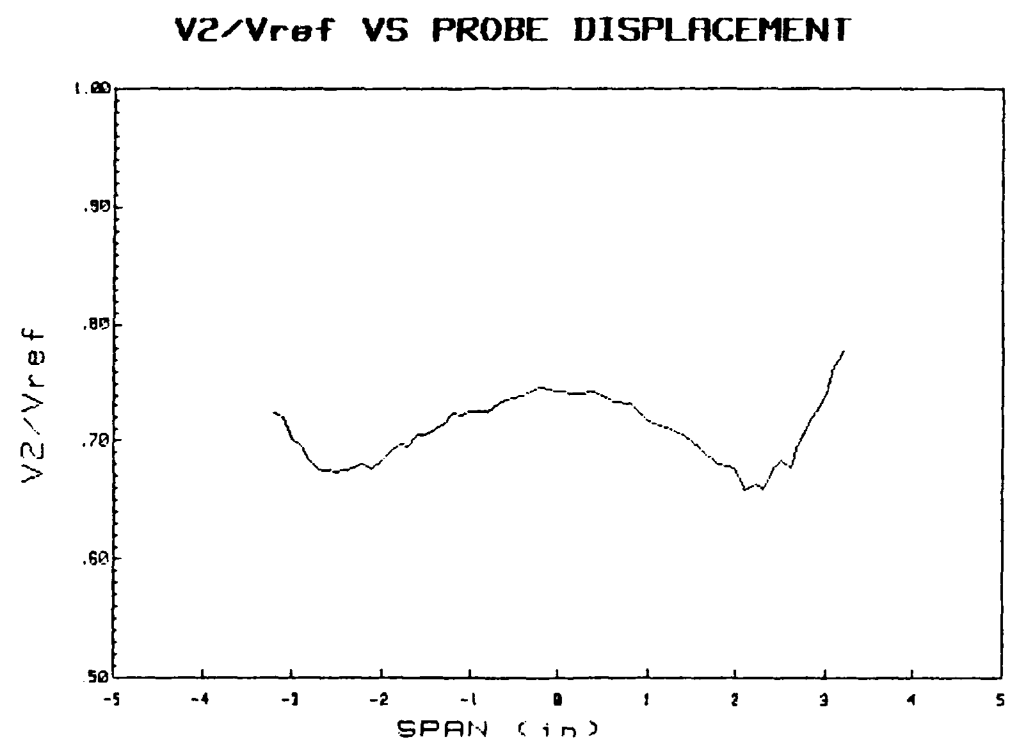


Figure 14. Outlet Survey: V2/Vref vs. Probe Displacement, Spanwise (Suction Side)

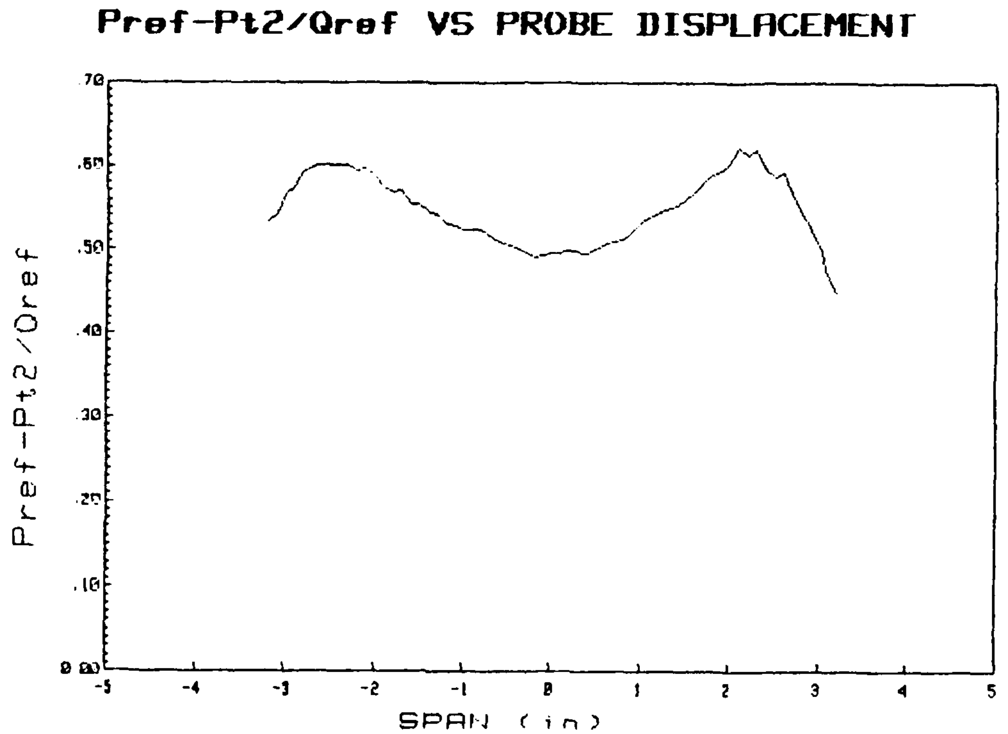


Figure 15. Outlet Survey: Pref-Pt2/Qref vs. Probe Displacement, Spanwise (Suction Side)

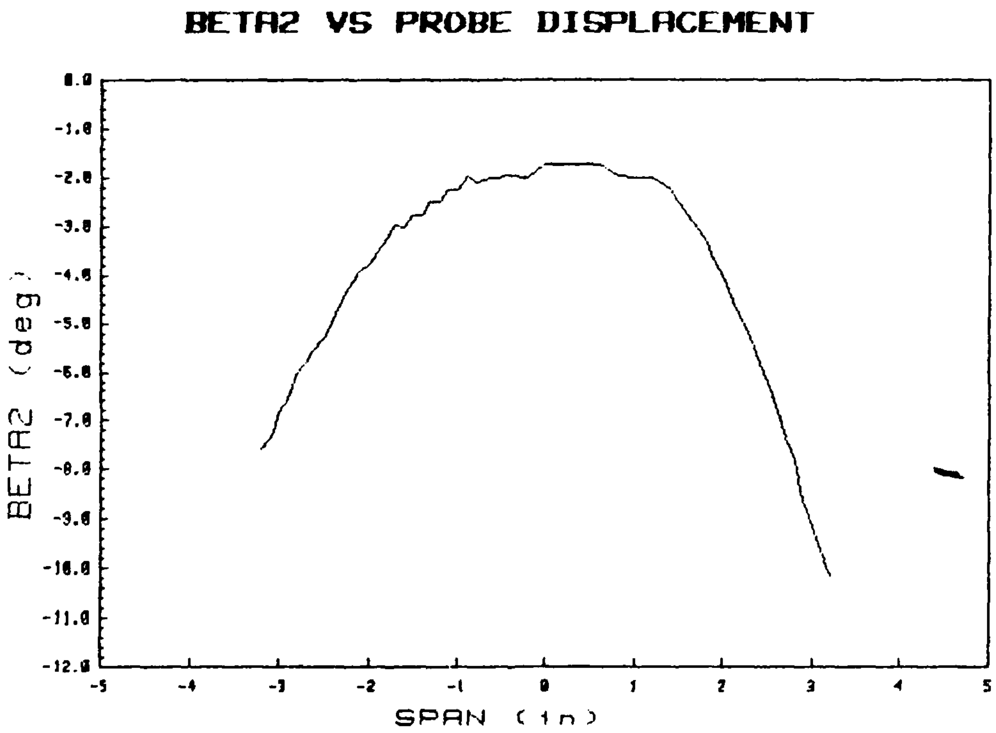


Figure 16. Outlet Survey: Beta2 vs. Probe Displacement Spanwise (Suction Side)

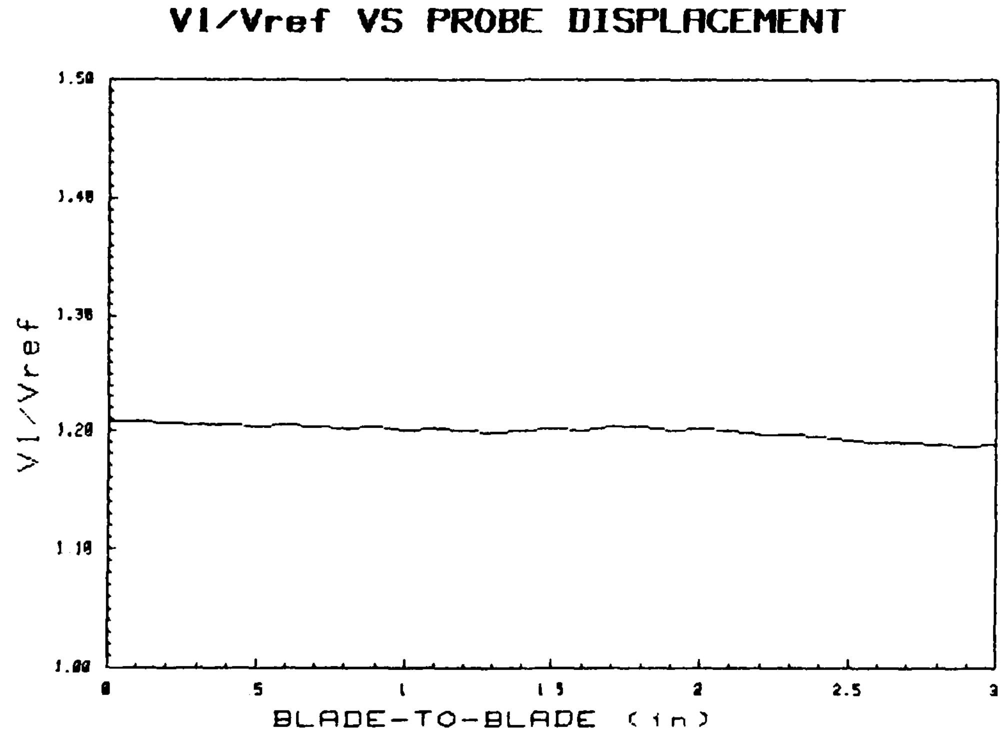


Figure 17. Loss Survey: V1/Vref vs. Probe Displacement, Blade-to-Blade

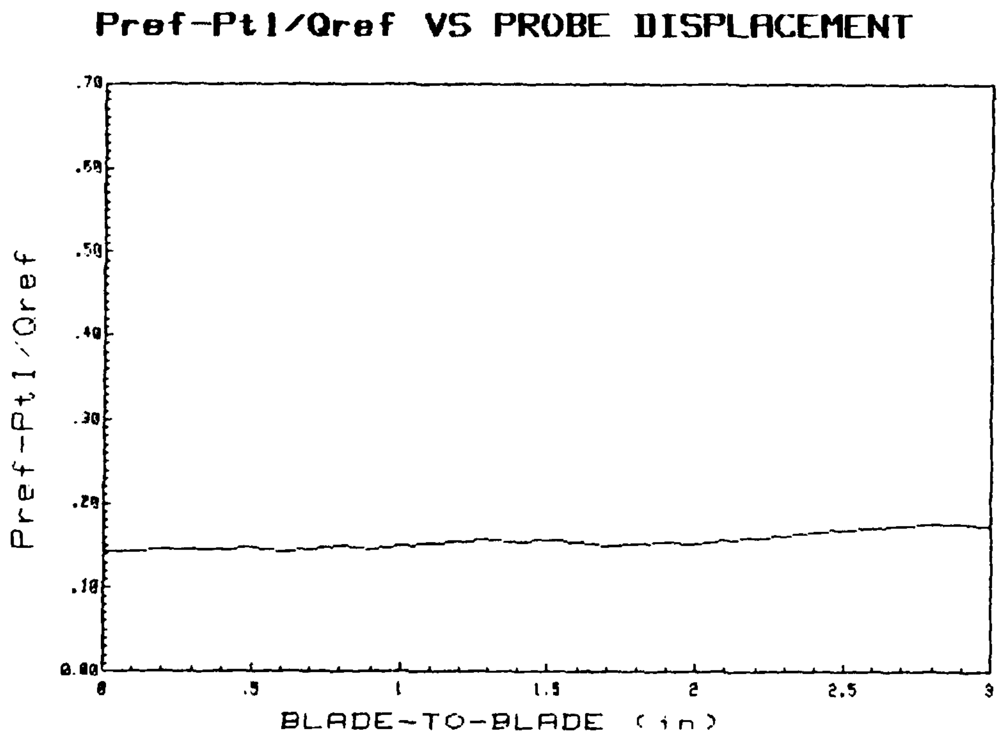


Figure 18. Loss Survey: Pref-Pt1/Qref vs. Probe Displacement, Blade-to-Blade

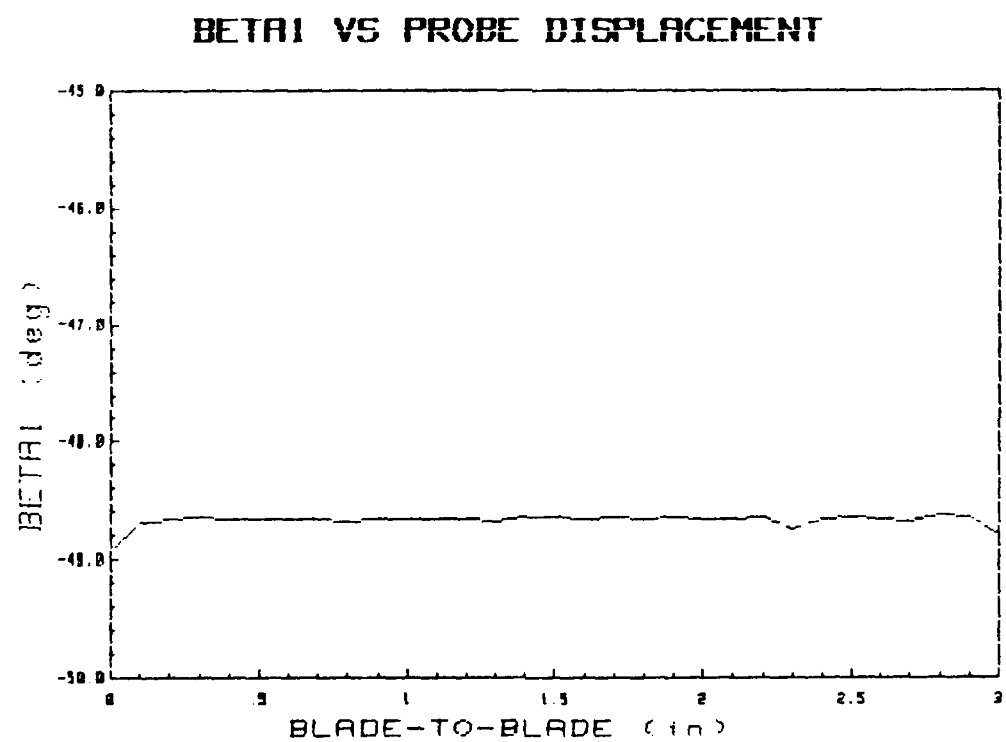


Figure 19. Loss Survey: Beta1 vs. Probe Displacement, Blade-to-Blade

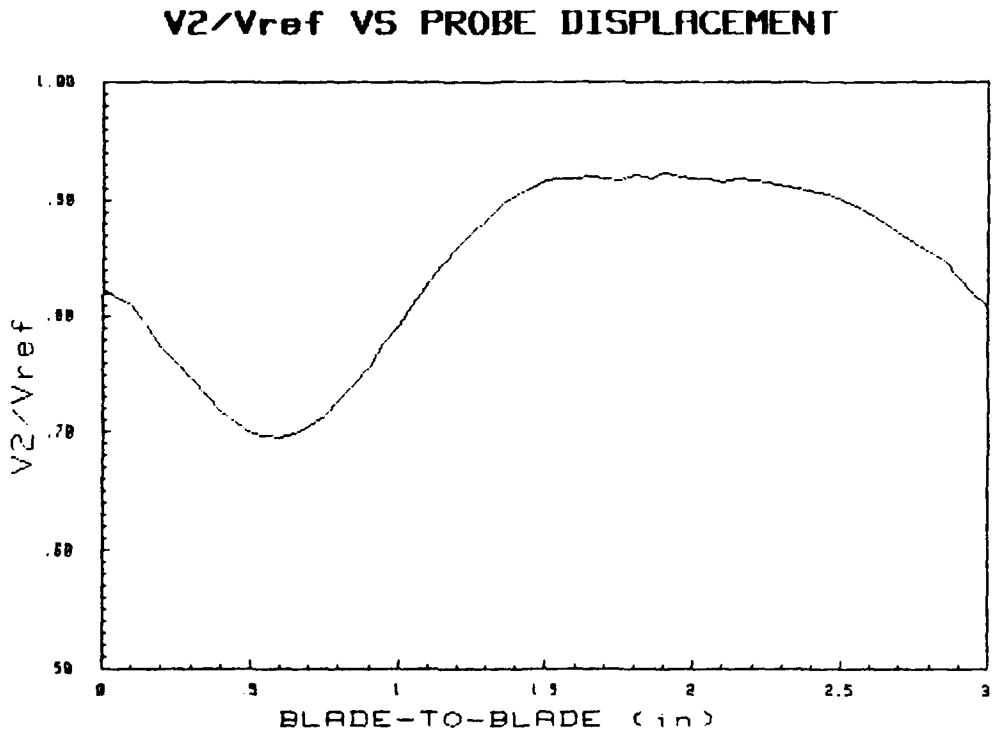


Figure 20. Loss Survey: V2/Vref vs. Probe Displacement, Blade-to-Blade

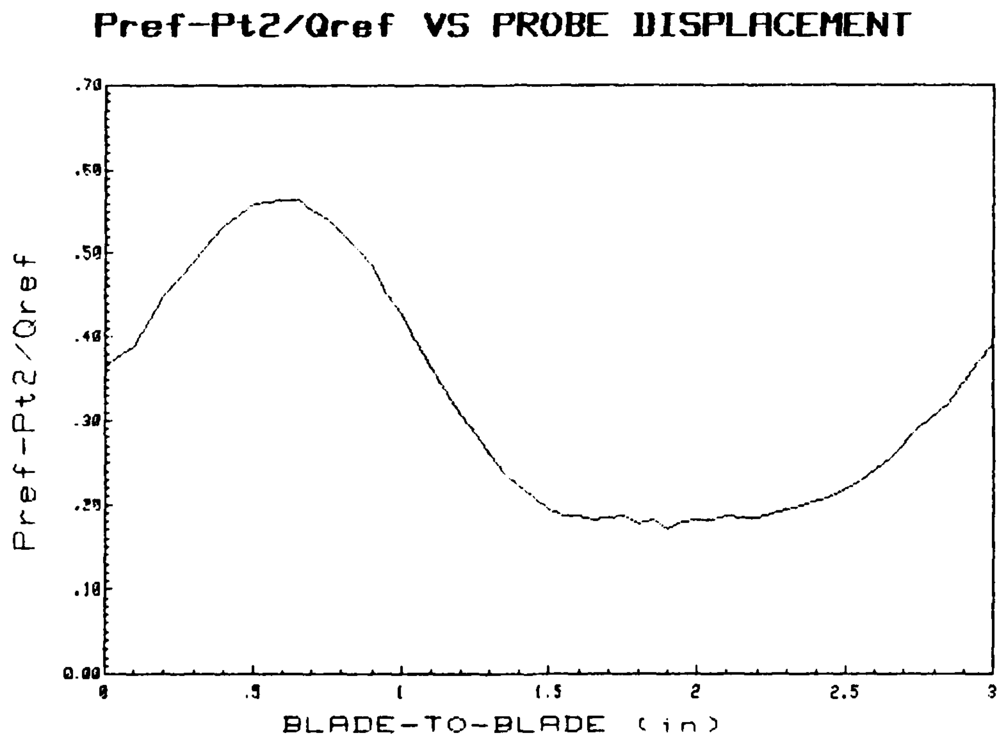


Figure 21. Loss Survey: Pref-Pt2/Qref vs. Probe Displacement, Blade-to-Blade

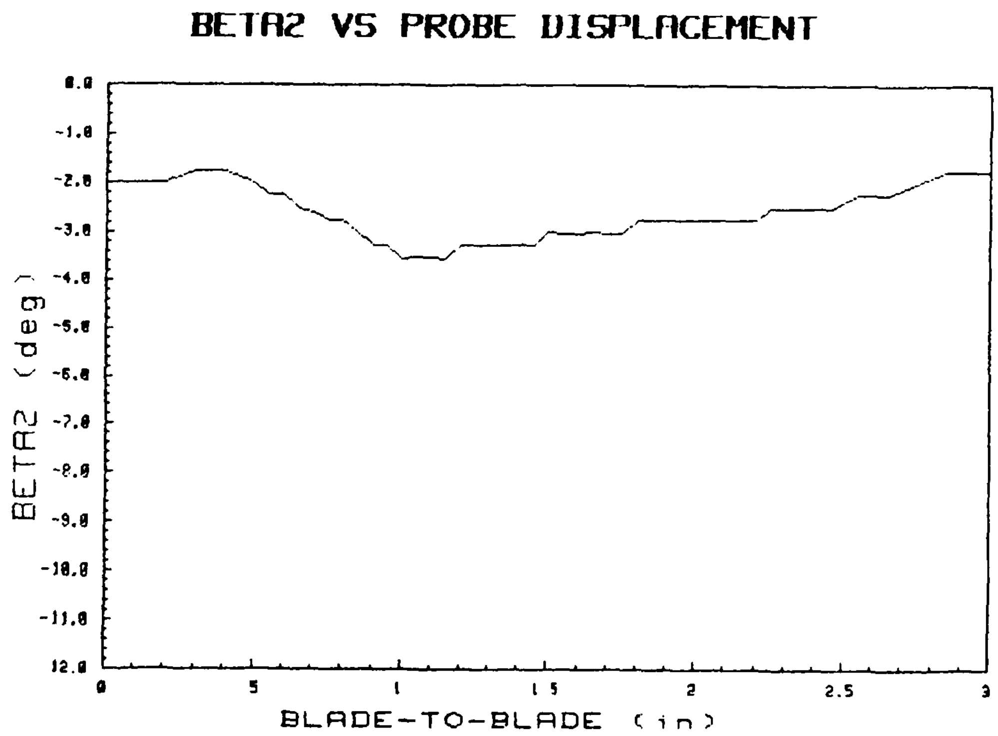


Figure 22. Loss Survey: Beta2 vs. Probe Displacement, Blade-to-Blade

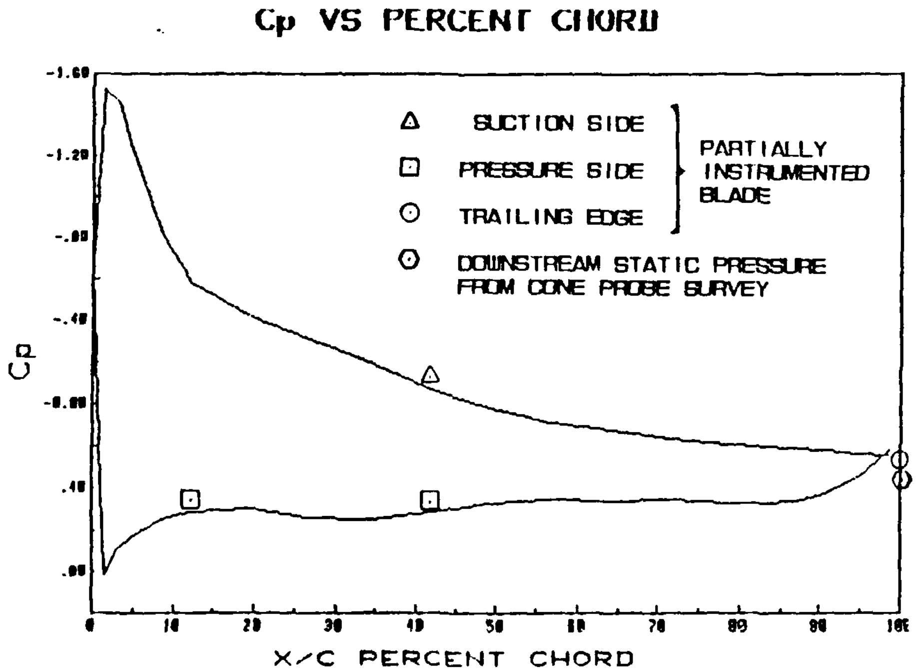


Figure 23. Surface Pressure Distribution:
Cp vs. X/C

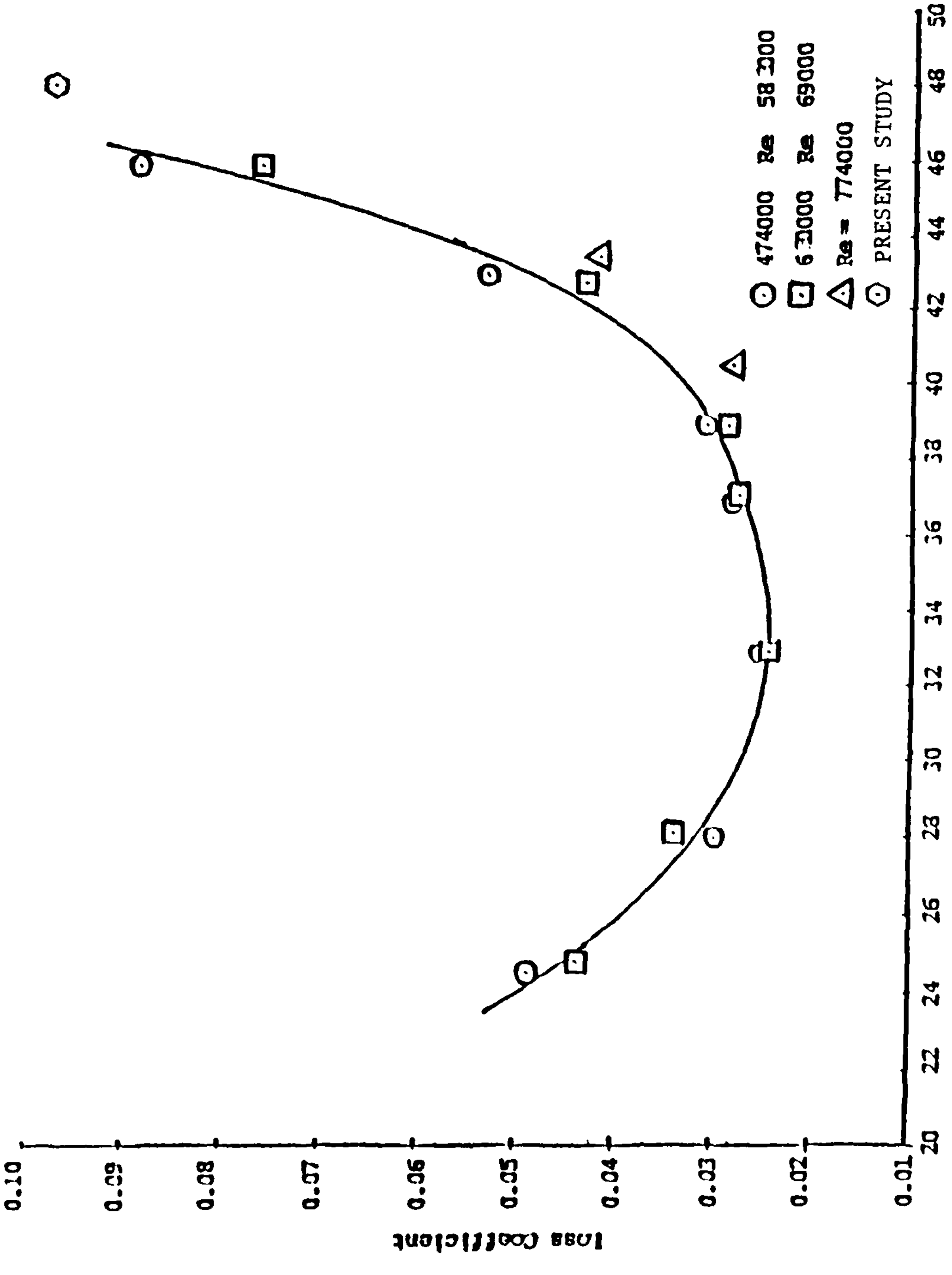


Figure 24. Loss Coefficient vs. Inlet
Air Angle

V. CONCLUSIONS AND RECOMMENDATIONS

Preliminary probe surveys were conducted at an inlet flow angle of 48 degrees using data acquisition software specifically written for the Hewlett Packard 300 PC and associated acquisition hardware. From the study, the following conclusions were drawn:

1. At an inlet flow angle of 48 degrees, there was a vanishing core of two-dimensional flow at the downstream survey station.

2. The blade-element performance quantities derived from the measurements were consistent with previous results at lower angle settings.

3. Software for calibrating five-hole pneumatic probes was revalidated and made available for use.

4. New software, for acquiring and reducing probe survey data to obtain the AVDR and loss coefficient, was written and verified.

5. The facility, instrumentation and procedures are available for making accurate off-design loss measurements on a routine basis.

Recommendations focus on improving results which can be obtained using pressure probe surveys in this facility.

(Recommendations concerning the software are given separately in Appendix B.) The recommendations are:

1. Make probe surveys closer to the trailing edge of the blade to reduce the effects of side-wall boundary layer buildup on the two-dimensionality of the flow.

2. Redesign the front wall of the cascade tunnel to be made of lighter materials and of modular construction. The present facility requires a high capacity overhead hoist to remove the wall to modify the cascade geometry. The modular construction would provide the means to expand the coverage of pneumatic and hot-wire probe surveys without sacrificing the quality of the flow through the test section. A design with interchangeable window and survey panels would provide greater access for the LDV.

3. Dreon's [Ref. 4] recommendations concerning calibrating the probe in yaw and automating the probe traverses are reiterated.

4. Incorporate the use of highly accurate linear variable displacement transducers (LVDT) in implementing item 3.

5. Consideration should be given to using two probes simultaneously to conduct the survey (the software has this provision) to avoid the danger of damaging the

probe during transfer to and from the upper and lower traverse slots.

6. Use the LDV system to obtain an accurate probe angle reference as shown in Appendix C.

7. At the present and any higher inlet angle settings, fully map the downstream flow field to better establish flow quality and degree of two-dimensionality.

8. Extend the blade-to-blade surveys to conclusively establish periodicity.

9. Employ the cascade's boundary layer suction provision to extend the range of two-dimensional flow at high inlet flow angles.

APPENDIX A

PROBE CALIBRATION

A1. INTRODUCTION

A five-hole conical probe was calibrated in a 7" free jet facility. The calibration process involved acquiring the data necessary to calculate the probe coefficients, beta and gamma, for various probe pitch angles and free jet flow velocities. Beta and gamma can be shown (Appendix A, Ref. 12) to be functions of Mach number and pitch angle (phi) when the probe is balanced (no yaw). The values of beta and gamma over the range of flow velocities and pitch angles tested are, in turn, used to determine a set of probe calibration coefficients for polynomial expressions for Mach number and phi in terms of beta and gamma [Ref. 12]. From the polynomial expressions, the Mach number and pitch angle can be determined when the five-hole pneumatic probe is immersed and balanced in an unknown flow.

In the reduction program "CALC" [Appendix B], beta and gamma are calculated from the pressures sensed by the probe. The files containing the probe calibration coefficients are accessed by "CALC" and the coefficients are made available to the subprogram Xphicalc where the non-dimensional velocity X and pitch angle phi are calculated. The relation between X, Mach number and other quantities involved in the calculation of the loss coefficient can be seen in Table I.

Section A2 describes the calibration apparatus. The calibration test program is addressed in Section A3. Results and discussion in Section A4 are followed by Recommendations in Section A5. Tables of data produced during the calibration of the cone probe used in the present study are contained in Section A6.

The following is a list of symbols used in Appendix A:

PA	Atmospheric Pressure
PK	Total pressure as sensed by the Kiel probe.
P1 - P5	Probe pressure parts as shown in Fig. A2.
P23	(P2 + P3)/2

A2. PROBE CALIBRATION APPARATUS

A2.1 Hardware

An illustration of the probe calibration apparatus and picture of the probe are shown in Fig. A1 and Fig. A2 respectively. The probe port numbering is also shown in Fig. A2. The 7 inch diameter free jet receives air from the Allis Chalmers compressor. Flow rate is controlled by a hand operated valve near the free jet attachment to the settling chamber. Honeycomb flow straighteners remove swirl and the nozzle acceleration generates a nearly uniform velocity profile at the probe.

A United Sensor 5-hole conical probe, #DC-125-24-F-22-065-4" was mounted vertically on top of the free jet frame. A special mount allowed the probe to be yawed, pitched and translated i.e., the immersion distance

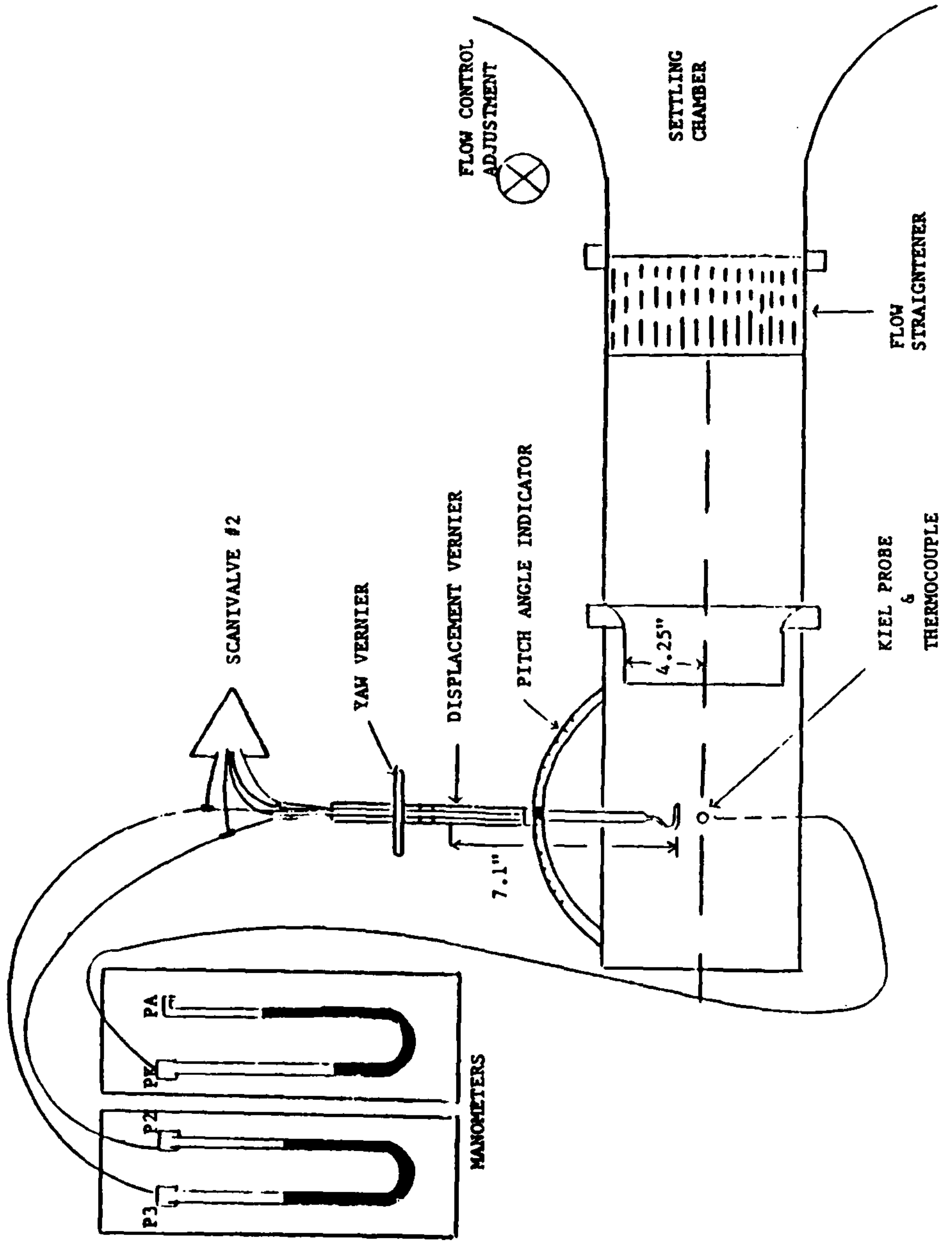


Figure A1. Probe Calibration Apparatus

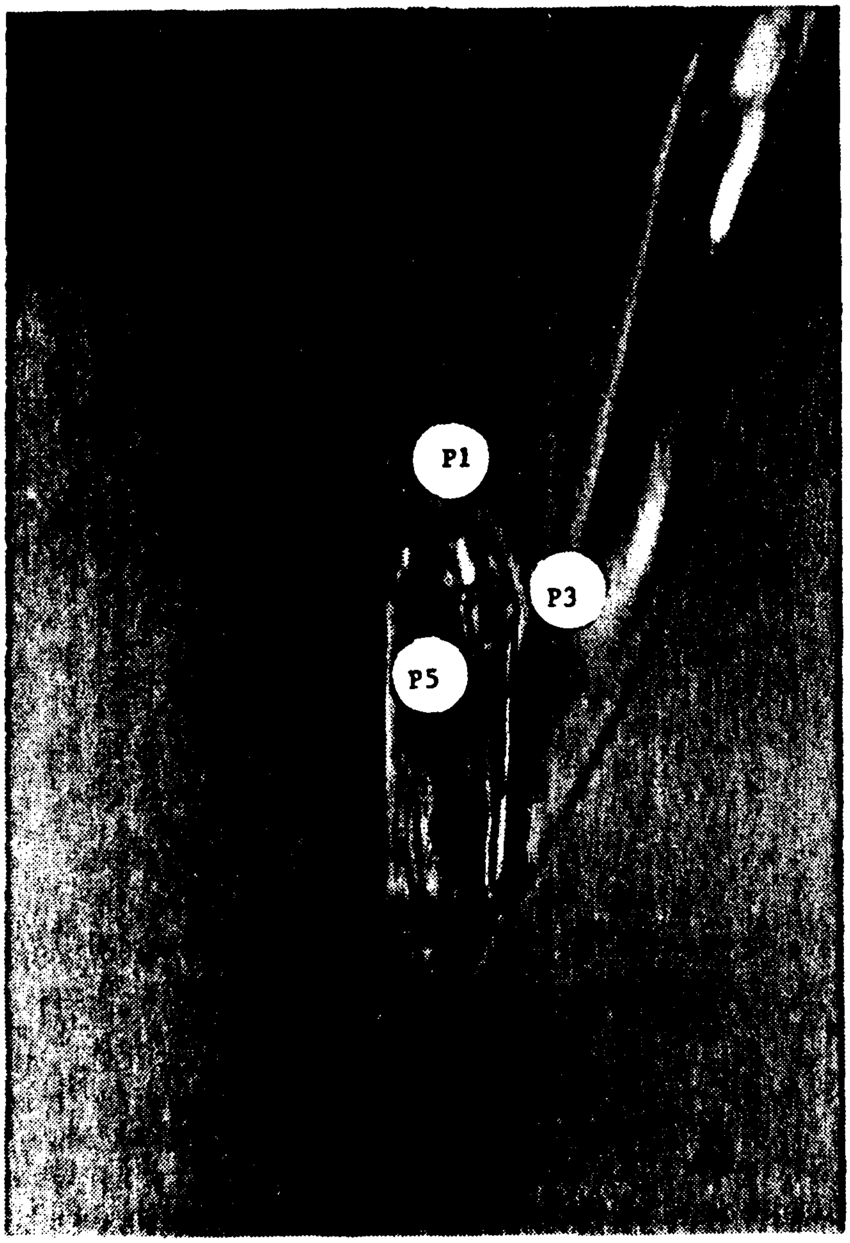


Figure A2. Five-Hole Conical Probe

could be varied. In this case, the immersion distance was fixed to read 7.1 on the vernier, allowing the probe to be rotated about its tip.

A combination Kiel and thermocouple probe was mounted horizontally and positioned into the flow to read total pressure and temperature.

Two water manometers were mounted next to the free jet. Pressures from conical probe ports 2 & 3 were fed to each side of one manometer, thus allowing the probe to be balanced in yaw. Total pressure as sensed by the Kiel probe (PK) was fed to the other manometer to allow the total flow of the free jet to be adjusted and monitored.

A Scanivalve rated at 2.5 psid sampled the conical probe pressures in addition to the Kiel probe and atmospheric pressures. A scanner, Scanivalve controller, and digital voltmeter (DVM) were used in conjunction with the Scanivalve to convert the pressures to digital form for subsequent storage and reduction.

Data acquisition software was run on the Hewlett Packard 9830 computer and associated peripheral components. The HP 9830 system primarily was used to record, store, and reduce the Scanivalve and thermocouple output while the HP 21MX system performed the calculations to generate the probe calibration coefficients.

A2.2 Software

The primary acquisition program was PRBCAL. Entries consisted of atmospheric pressure in inches Hg, number of

separate probe pitch angles (maximum of 12), Scanivalve number, temperature channel and number of samples to average (normally five). The program acquired the data for each probe pitch setting, then stopped to allow the user to change the pitch setting and balance the probe before data was again acquired. After all pitch settings had been sampled, the program prompted the user for a six element alphanumeric file name for the data to be stored. This file had to be opened prior to running PRBCAL. After the file name was entered in response to the prompt, the reduced data was printed in the form of Tables A1 - A3.

The program PRBRED generated probe coefficients and other parameters from the PRBCAL data files. PRBRED, used in conjunction with the "KEY" program PLOTK, allowed probe coefficients to be plotted against pitch angles. The PLOTK program required some familiarity with Hewlett Packard plotting procedures.

CALI2 provided the means to transfer data files from the HP 9830 system to the HP 21MX system. This was required since the 9830 system does not have the capability to generate the calibration coefficients. PRBCAL, PRBRED, PLOTK & CALI2 were on disc SHREEVE P007.

A data transfer program, also named CALI2, was loaded and run on the HP 21MX when CALI2 was run on the HP 9830. The raw data files were transferred and probe calibration quantities were calculated by the HP 21MX programs as shown in Tables A4 and A5. The program JOHN3 combined the

TABLE A1. TABULATED SCALED DATA OUTPUT BY PRBCAL (DATAFILES CV = 100; CV = 150)

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES(IN.H20)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
-0.0040	34.518 **	2.4020	-0.1630	0.2420	-0.4740	2.336 **	-6.0
-0.0240	34.468 **	2.4120	-0.1430	0.1180	-0.3980	2.340 **	-4.0
-0.0400	-0.048 **	2.3260	-0.1270	0.0820	-0.3580	2.316 **	-3.0
-0.0240	-0.030 **	2.33[illegible]0	-0.1270	0.0540	-0.3180	2.354 **	-2.0
-0.0520	-0.044 **	2.3180	-0.1180	0.0120	-0.2500	2.326 **	-1.0
-0.0360	-0.036 **	2.3020	-0.1240	-0.0320	-0.2180	2.342 **	0.0
-0.0440	-0.058 **	2.2780	-0.1380	-0.1266	-0.1980	2.306	1.0
-0.0500	-0.020 **	2.3280	-0.1160	-0.1140	-0.1220	2.338	2.0
-0.0340	-0.054 **	2.2980	-0.1270	-0.1720	-0.0980	2.318 *	3.0
-0.0480	-0.050 **	2.3180	-0.1290	-0.2300	-0.0260	2.320 **	4.0
-0.0420	-0.046 **	2.2960	-0.1100	-0.2560	0.0200	2.344 **	6.0

ATMOS. PRESS. (IN.HG)	TEMPERATURE (F)
30.06	98.61
30.06	99.43
30.06	100.07
30.06	100.58
30.06	100.92
30.06	101.29
30.06	101.32
30.06	101.60
30.06	101.76
30.06	101.93
30.06	102.27

DATA STORED IN CV=100

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES(IN.H20

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
0.0540	32.900 **	5.3300	-0.3430	0.5460	-1.0200	5.326 **	-6.0
0.0200	32.924 **	5.3360	-0.3010	0.3300	-0.8540	5.284 **	-4.0
0.0760	-0.032 **	5.2540	-0.2820	0.1760	-0.8115	5.292 **	-3.0
-0.0260	-0.012 **	5.2580	-0.2680	0.1040	-0.6980	5.320 **	-2.0
-0.0040	-0.010 **	5.2560	-0.2680	0.0100	-0.6220	5.292 **	-1.0
-0.0360	-0.028 **	5.2520	-0.2480	-0.0920	-0.5320	5.306 **	0.0
-0.0600	-0.072 **	5.2940	-0.2330	-0.1640	-0.4160	5.314 **	1.0
-0.0640	-0.066 **	5.2740	-0.2270	-0.2380	-0.2920	5.338 **	2.0
-0.0900	-0.086 **	5.2940	-0.2120	-0.3200	-0.1940	5.346 **	3.0
-0.0740	-0.064 **	5.2260	-0.2410	-0.4380	-0.1140	5.276 **	4.0
-0.1000	-0.098 **	5.2560	-0.2630	-0.6000	0.1060	5.332	6.0

ATMOS. PRESS. (IN.HG)	TEMPERATURE (F)
30.09	109.50
30.09	109.70
30.09	109.70
30.09	109.73
30.09	109.70
30.09	109.77
30.09	109.70
30.09	109.77
30.09	109.80
30.09	109.77
30.09	109.84

DATA STORED IN CV=150

TABLE A2. TABULATED SCALED DATA OUTPUT BY PRBCAL (DATA FILES CV = 200, CV = 250)

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES(IN.H20)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA ** PHI
0.0100	0.014 **	9.1660	-0.6360	0.9560	-1.8500	9.350 ** -6.0
-0.0160	-0.014 **	9.2660	-0.5700	0.5680	-1.5600	9.364 ** -4.0
-0.0520	-0.062 **	9.2540	-0.5410	0.3980	-1.4320	9.348 ** -3.0
-0.0700	-0.070 **	9.3000	-0.5010	0.1730	-1.2740	9.380 ** -2.0
-0.0400	-0.030 **	9.3100	-0.4610	0.0500	-1.0940	9.372 ** -1.0
[redacted]						
-0.0160	-0.020 **	9.3000	-0.4860	-0.3420	-0.7820	9.352 ** 1.0
-0.0200	-0.024 **	9.2560	-0.4690	-0.4860	-0.6080	9.344 ** 2.0
-0.0380	-0.044 **	9.2840	-0.4530	-0.6240	-0.4380	9.364 ** 3.0
-0.0320	-0.032 **	9.2140	-0.4670	-0.7720	-0.2440	9.326 ** 4.0
-0.0300	-0.024 **	9.2360	-0.5190	-1.1000	0.1280	9.334 ** 6.0

ATMOS. PRESS. (IN.HG)	TEMPERATURE (F)
30.10	108.45
30.10	108.38
30.10	108.24
30.10	108.34
30.10	108.55
30.10	108.75
30.10	108.72
30.10	108.72
30.10	108.75
30.10	108.85
30.10	108.99

DATA STORED IN CV=200

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES(IN H20)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA ** PHI
0.1040	32.980 **	14.4320	-1.1430	1.1300	-3.1100	14.550 ** -6.0
-0.3100	32.978 **	14.6340	-0.8610	0.8380	-2.5020	14.650 ** -4.0
-0.0160	32.970 **	14.5880	-0.8090	0.6160	-2.2320	14.660 ** -3.0
-0.0460	32.884 **	14.7120	-0.7780	0.3180	-1.9940	14.688 ** -2.0
-0.0140	32.648 **	14.6840	-0.7630	0.0380	-1.7480	14.644 ** -1.0
-0.0320	-0.024 **	14.6080	-0.7250	-0.2260	-1.4880	14.764 ** 0.0
-0.0620	-0.050 **	14.6960	-0.6750	-0.4500	-1.2160	14.782 ** 1.0
-0.2620	-0.258 **	14.7620	-0.4910	-0.4380	-0.7800	14.880 ** 2.0
-0.0400	-0.050 **	14.5180	-0.7320	-1.0340	-0.7520	14.622 ** 3.0
-0.0720	-0.060 **	14.5300	-0.7760	-1.2980	-0.4720	14.684 ** 4.0
-0.0580	-0.056 **	14.6380	-0.8880	-1.9160	0.0960	14.750 ** 6.0

ATMOS. PRESS. (IN.HG)	TEMPERATURE (F)
30.11	107.26
30.11	107.12
30.11	107.12
30.11	107.12
30.11	107.09
30.11	107.19
30.11	107.26
30.11	107.26
30.11	107.29
30.11	107.16
30.11	107.33

DATA STORED IN CV=250

TABLE A3. TABULATED SCALED DATA OUTPUT BY PRBCAL (DATA FILES CV = 300)

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES(IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
0.0320	30.956 **	21.1960	-1.5050	2.2300	-4.3800	21.458 **	-6.0
-0.0080	30.188 **	21.3360	-1.2700	1.3200	-3.6400	21.480 **	-4.0
-0.0140	29.022 **	21.4420	-1.1880	0.9380	-3.3260	21.524 **	-3.0
0.0040	28.518 **	21.5880	-1.1510	0.4780	-2.9640	21.612 **	-2.0
-0.0280	27.730 **	21.4020	-1.1010	0.1000	-2.5800	21.448 **	-1.0
0.0040	27.048 **	21.3080	-1.0380	-0.2920	-2.2020	21.334 **	0.0
-0.0120	26.554 **	21.3020	-1.0220	-0.7100	-1.7840	21.352 **	1.0
-0.0260	25.724 **	21.3680	-1.0270	-1.1540	-1.4600	21.538 **	2.0
-0.0480	25.240 **	21.5420	-1.0680	-1.5440	-1.0620	21.664 **	3.0
-0.0160	24.756 **	21.4160	-1.1220	-1.9800	-0.6700	21.542 **	4.0
-0.0040	24.156 **	21.4520	-1.3430	-2.1100	0.1400	21.656 **	6.0

ATMOS. PRESS. (IN.HG)	TEMPERATURE (F)
30.12	107.50
30.12	107.56
30.12	107.50
30.12	107.36
30.12	107.46
30.12	107.70
30.12	107.80
30.12	107.80
0.12	107.77
30.12	107.77
30.12	107.80

DATA STORED IN CV=300

TABLE A4. TABULATED REDUCED DATA OUTPUT BY CALI2 (DATA FILES CV = 100, CV = 150, CV = 200)

THE DATA FROM DATA SET # 1 OF FILE CV=100 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.006250	.279142	.001745	.040063	.089655	-6.000000	98.611176
.006225	.201257	.001257	.040269	.090118	-4.000000	99.425010
.005970	.179372	.001072	.040458	.090541	-3.000000	100.069310
.006007	.150913	.000907	.040307	.090383	-2.000000	100.578000
.005936	.107553	.000638	.040392	.090393	-1.000000	100.917100
.005913	.076669	.000453	.040390	.090309	0.000000	101.270100
.005988	.029001	.000175	.040154	.089058	1.000000	101.324010
.005956	.003273	.000019	.040476	.090581	2.000000	101.595310
.005910	-.030515	-.000180	.040168	.089892	3.000000	101.764000
.005963	-.083367	-.000497	.040306	.090201	4.000000	101.934000
.005864	-.114713	-.000673	.040458	.090541	6.000000	102.273500

THE DATA FROM DATA SET # 1 OF FILE CV=150 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.013711	.276044	.003785	.060288	.136177	-6.000000	109.426310
.013625	.210041	.002862	.060359	.135212	-4.000000	107.692800
.013303	.170380	.002387	.060438	.135390	-3.000000	109.699800
.013359	.145132	.001939	.060595	.135744	-2.000000	109.733700
.013355	.114410	.001528	.060312	.135108	-1.000000	109.699800
.013296	.081818	.001088	.060573	.135696	0.000000	109.767500
.013359	.045594	.000609	.060754	.136102	1.000000	109.699800
.013256	.009816	.000131	.060911	.136455	2.000000	109.767500
.013307	-.022891	-.000305	.061103	.136885	3.000000	109.801500
.013215	-.059265	-.000703	.060620	.135799	4.000000	109.767500
.013339	-.127922	-.001706	.061080	.136835	6.000000	109.835400

THE DATA FROM DATA SET # 1 OF FILE CV=200 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.023168	.286268	.006718	.079903	.179242	-6.000000	108.445100
.023542	.216348	.005093	.080072	.179624	-4.000000	108.377300
.023443	.186830	.004380	.080158	.179817	-3.000000	108.241520
.023454	.146108	.003427	.080369	.180293	-2.000000	108.343400
.023383	.117001	.002738	.080208	.179931	-1.000000	108.546800
.023077	.078790	.001824	.079624	.178612	0.000000	108.750310
.023421	.044962	.001053	.080022	.179511	1.000000	108.716400
.023277	.012545	.000292	.080005	.179172	2.000000	108.716400
.023303	-.019102	-.000445	.080166	.179835	3.000000	108.750310
.023173	-.054540	-.001264	.079981	.179417	4.000000	108.852010
.023349	-.125881	-.002939	.080006	.179474	6.000000	108.987500

TABLE A5. TABULATED REDUCED DATA OUTPUT BY CALI2
(DATA FILES CV = 250, CV = 300)

THE DATA FROM DATA SET # 1 OF FILE CV=250 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.036822	.272231	.010024	.098882	.222196	-6.000000	107.258190
.036603	.219426	.008032	.099707	.224068	-4.000000	107.122600
.036375	.184271	.006728	.099734	.224129	-3.000000	107.122600
.036504	.149250	.005460	.099826	.224339	-2.000000	107.122600
.036487	.115621	.004219	.099573	.223764	-1.000000	107.088700
.036223	.082306	.002981	.100031	.224804	0.000000	107.190400
.036303	.049444	.001795	.100191	.225166	1.000000	107.258190
.036001	.018488	.000666	.101176	.227402	2.000000	107.258190
.036034	-.018492	-.000666	.099587	.223796	3.000000	107.292100
.036163	-.053766	-.001952	.099900	.224507	4.000000	107.156470
.036674	-.129589	-.004753	.100071	.224896	6.000000	107.326100

THE DATA FROM DATA SET # 1 OF FILE CV=300 ARE

.052799	.251177	.015374	.120303	.270974	-6.000000	
.052556	.219411	.011531	.120471	.271359	-4.000000	107.563400
.052590	.183122	.009911	.120607	.271660	-3.000000	107.495610
.052036	.151370	.007998	.120796	.272101	-2.000000	107.360000
.052306	.119095	.006229	.120439	.271284	-1.000000	107.461700
.051956	.085474	.004441	.120042	.270377	0.000000	107.699100
.051904	.048110	.002497	.120135	.270589	1.000000	107.800800
.052059	.013664	.000711	.120678	.271830	2.000000	107.800900
.052535	-.021318	-.001120	.121070	.272744	3.000000	107.766910
.052387	-.050390	-.003059	.120661	.271793	4.000000	107.766910
.052981	-.142575	-.007554	.120937	.272423	6.000000	107.800000

separate files generated during CALI2 execution into a single file consistent with the format required for the JOHN4 program. (A tabulation of JOHN3 data is not included since the quantities are the same as those listed in the separate files of CALI2.) JOHN4 produced a surface plot of the data (Figs. A3 and A4) and generated a matrix of the probe calibration coefficients (Table A6). Figures A3 and A4 are plots of the actual data generated from the probe calibration process, while the ERRORS (%) at each point in Table A6 quantitatively show the difference between the data points in Figures A3 and A4 and the "best fit" surface at the given values of beta and gamma. The "best fit" surface was given by the polynomial expressions previously cited [Ref. 12] using the matrix of calibration coefficients produced by JOHN4, and tabulated in Table A6. JOHN4 produced a matrix of coefficients and also associated tabulation of errors at each point for increasingly higher order polynomials. The user was required to make the choice of what order polynomial gave the best fit to the actual data by an examination of the errors at each point, associated with the use of polynomials of different orders. It is noted that the program prompts the user for the M and N order of the "best fit" polynomial. The coefficients are presented in an M by N matrix where M represents column values and N represents row values. <u>The polynomial order entered is thus, M-1 and N-1</u>, since the polynomial order is one less than the number of coefficients that it requires.

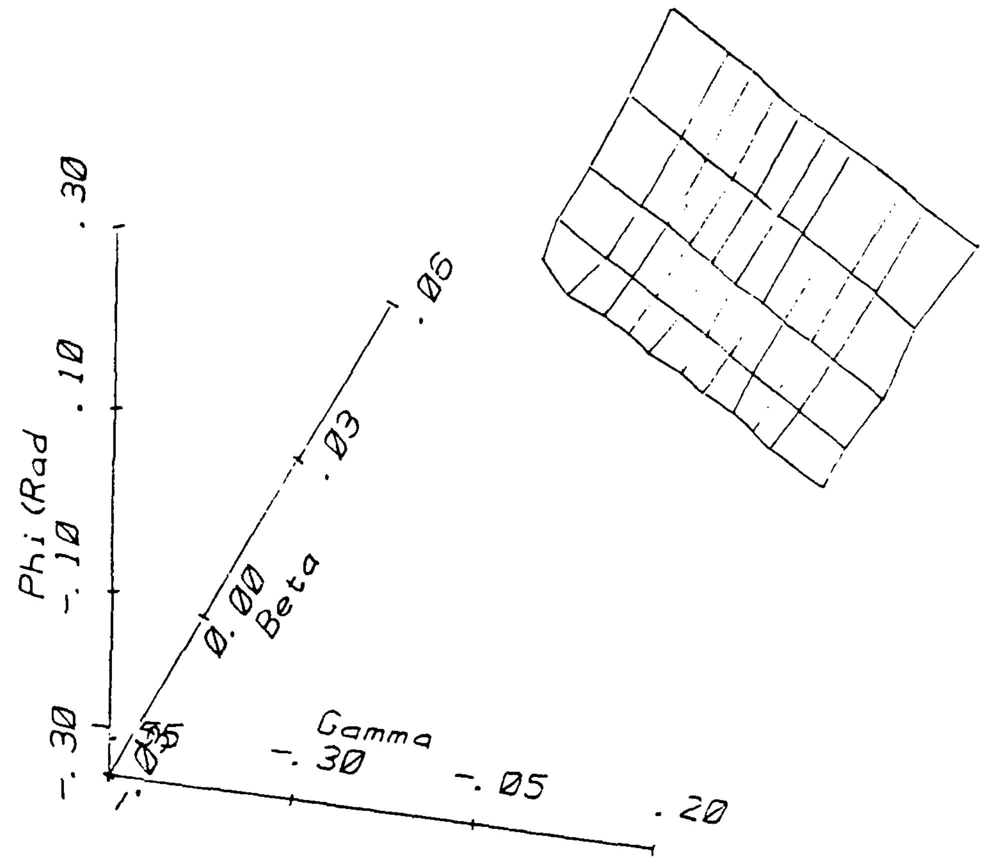


Figure A3. Surface Plot of Phi. vs. Gamma and Beta

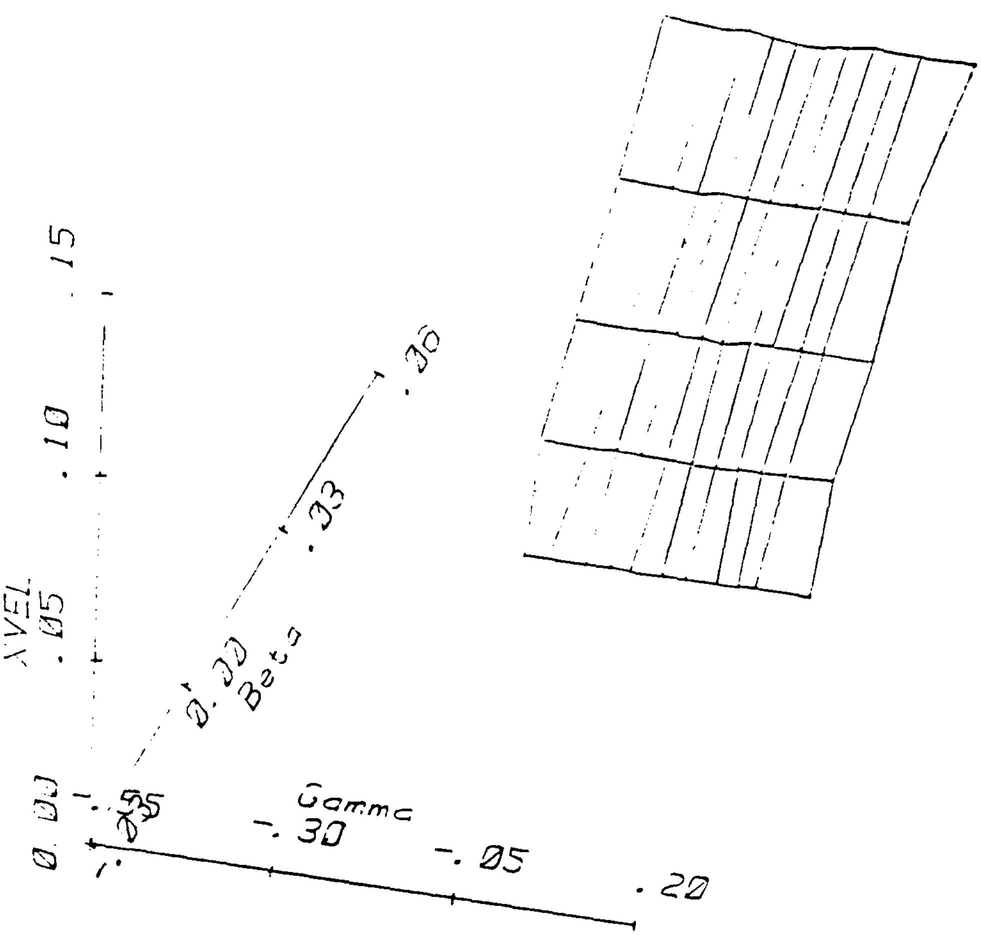


Figure A4. Surface Plot of X (velocity) vs. Gamma and Beta

TABLE A6. BEST FIT CALIBRATION COEFFICIENTS SELECTED USING JOHN4 WITH ASSOCIATED ERRORS

COEFFICIENTS FOR THE CALIBRATION SURFACE STORED IN FILE :MIKEC3

	1	2	3	4	5
1	.015976	4.932133	-153.668740	3137.961400	-24299.0050
2	-.003563	.697505	-62.977264	2068.372100	-20872.1400
3	.080098	-24.844173	1980.495400	-57799.7030	541835.5000
	1	2	3	4	5

ERRORS(Z) AT EACH POINT

	1	2	3	4	5	6	7	8	9	10	11
1	-.556	-1.098	1.032	.319	.522	.479	-.135	-.007	-.467	-.575	.641
2	1.001	-.463	.161	.114	-.650	-.257	-.411	-.051	.173	-.252	.302
3	-.418	-.264	.076	.329	.273	.118	-.092	.137	.225	.101	-.359
4	.137	.325	.198	-.392	-.785	-.114	-.180	1.225	-.346	-.005	-.024
5	-.064	.139	.092	-.050	-.027	-.212	-.172	.166	.233	.026	-.007
	1	2	3	4	5	6	7	8	9	10	11

COEFFICIENTS FOR THE CALIBRATION SURFACE STORED IN FILE :MIKEC2

	1	2	3	4	5
1	.023535	3.178730	-199.593070	5134.302700	-45091.8900
2	-.557400	11.194368	-778.272950	21622.67100	-180556.340
3	.758150	-183.145780	12999.86900	-351917.690	3136833.000
	1	2	3	4	5

ERRORS(DEGREES) AT EACH POINT

	1	2	3	4	5	6	7	8	9	10	11
1	-.071	-.258	.097	.288	.049	.158	-.205	.010	-.013	-.569	.486
2	.084	-.017	-.004	-.032	.030	.049	-.028	-.075	-.018	-.051	.041
3	-.049	-.056	.094	-.083	.075	-.034	-.026	.025	.096	.053	-.056
4	-.079	.176	.071	-.047	-.080	-.078	-.050	.059	.006	.016	-.008
5	.060	-.054	.019	-.069	-.000	.008	-.053	.006	.097	.102	-.084
	1	2	3	4	5	6	7	8	9	10	

A3. TEST PROGRAM AND RESULTS

The calibration was conducted at five flow velocities: nominally 100, 150, 200, 250 and 300 ft/sec. At each velocity, the probe was moved to -6, -4, -3, -2, -1, 0, 1, 2, 3, 4, 6 degrees of pitch (phi) and balanced so probe port P2 and P3 pressures were equal on the manometer. The data were stored in files CV=100 to CV=300 on disc SHREEVE PØØ7.

Prior to the calibration, a survey of the free jet was conducted at a flow of approximately 200 ft/sec to determine the velocity profile. The survey was conducted from top to bottom and, with the probe mounted on the underside, from bottom to top. There was some overlap in the survey, which in principle, would allow the departure of the jet flow direction from true axial to be resolved by the pitch angle indicated from the two sides.

Data collected in files CV=100, CV=200 and CV=300 and subsequently reduced by PRBRED were handplotted to show the effect of pitch angle on the coefficients. Fig. A5 shows phi vs. beta, where beta = (P1-P23)/P1. Fig. A6 is a plot of phi vs. betabar, where betabar = beta/(PK-PA)/PK). Phi vs gamma (P1-P4/P1-P23) is shown in Fig. A7 and phi vs. (P1-PK)/(PK-PA) is plotted in Fig. A8. Free jet survey results are shown in Fig. A9.

A4. DISCUSSION

The probe calibration data presented in Figs. A3-A9 are well-behaved and qualitatively consistent with the

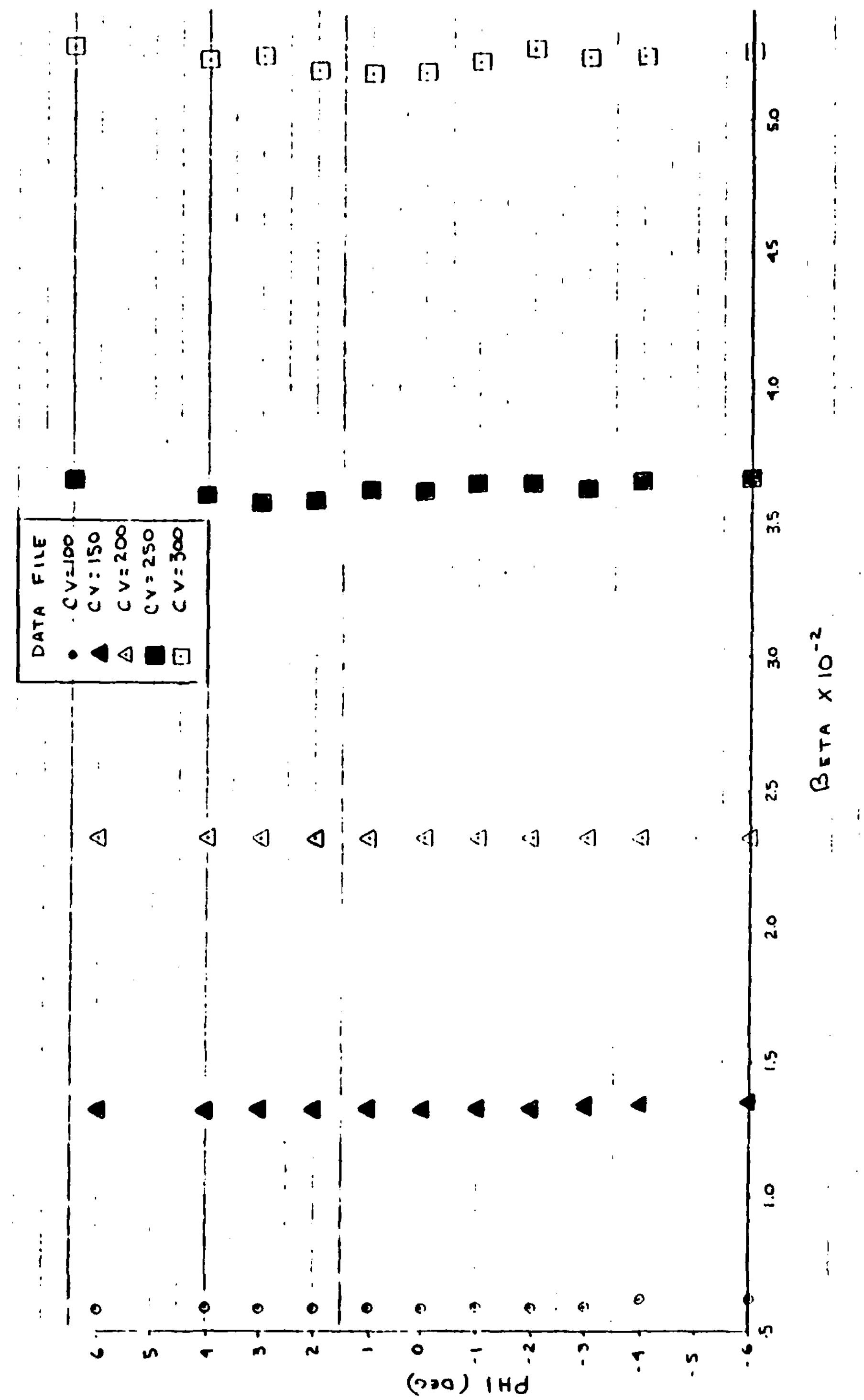


Figure A5. Phi vs. Beta

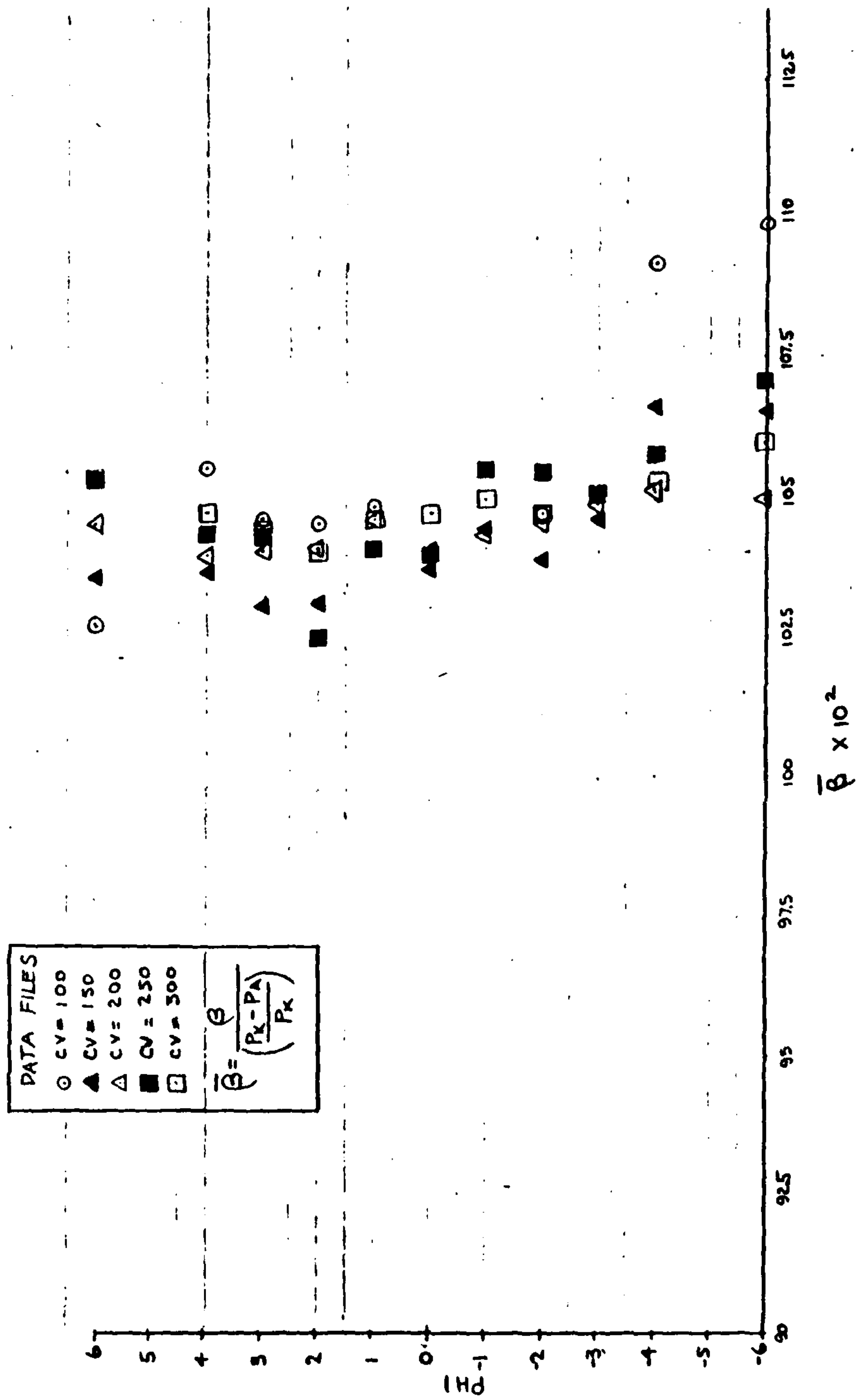


Figure A6. Phi vs. Betabar

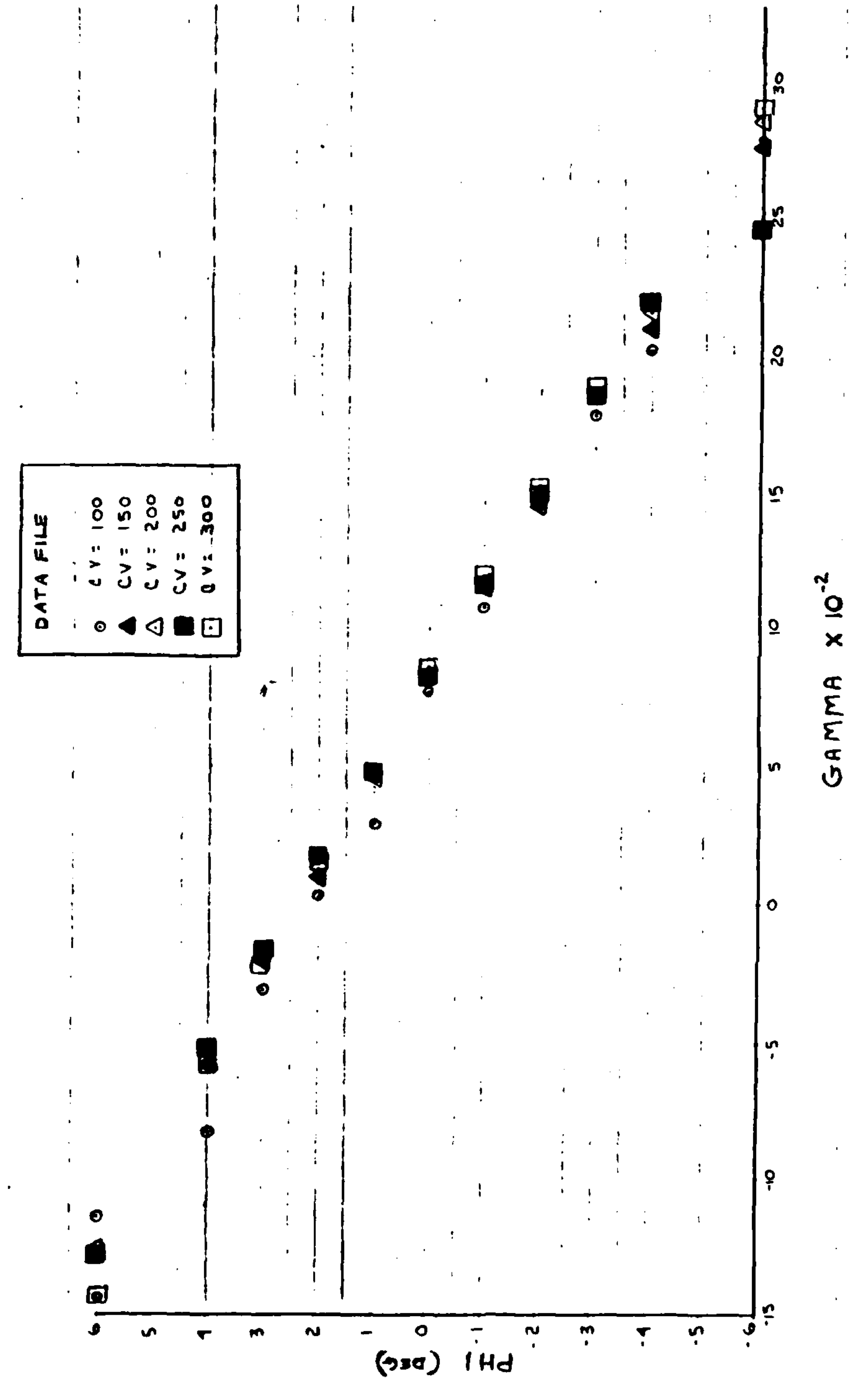


Figure A7. Phi vs. Gamma

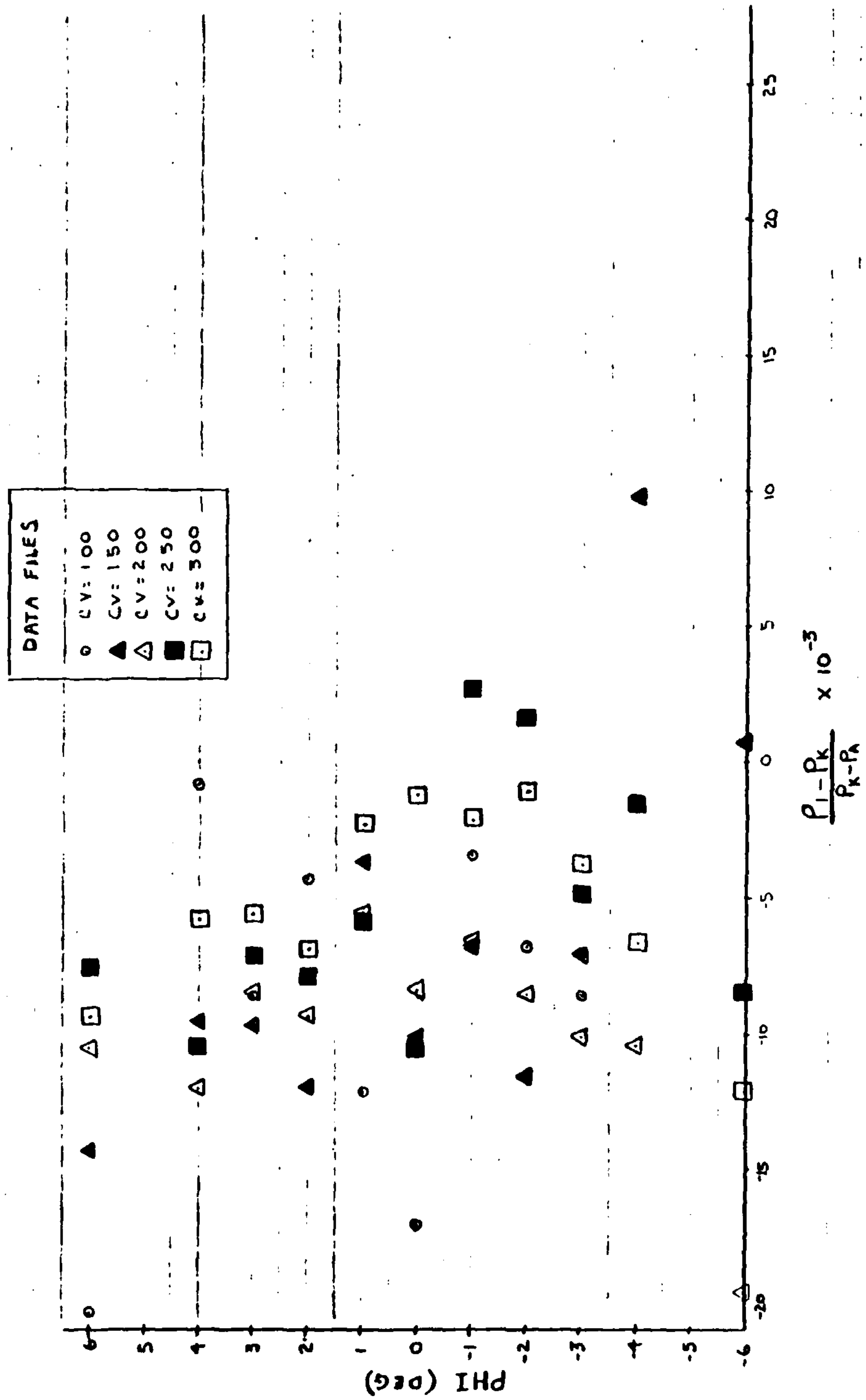


Figure A8. Phi vs. (P1 - PK)/(PK - PA)

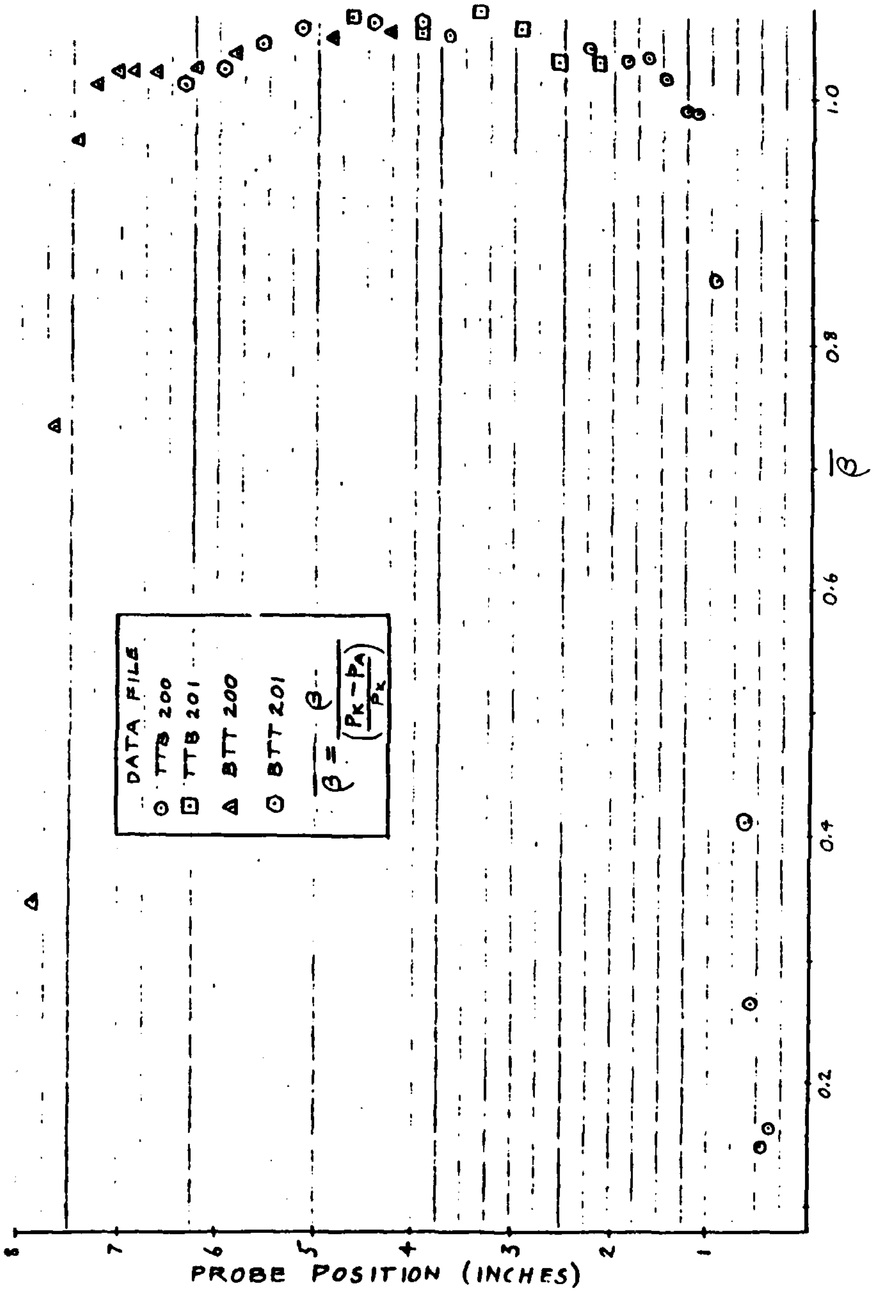


Figure A9. Free Jet Survey: Probe Position vs. Betabar

experience of previous investigators [Ref. 4 and Ref. 12]. Data quality and probe characteristics can be determined from the quantities plotted in these figures. A discussion of the results in each plot follows.

Appendix A of Ref. 12 shows that beta is a function of the non-dimensional velocity X and phi with strongest dependence on X; gamma is a function of X and phi but most strongly dependent on phi. Fig. A5 shows that as the pitch angle was changed, there was very little change in beta for a given flow velocity. Since beta is related to velocity as developed in Appendix A, Ref. 12, the plot implies that there was a very small change in the measured velocity by the probe with pitch variation, or that beta is slightly sensitive to pitch. The greatest variation in beta is seen in the data from file CV = 300. Beta varied by about 1.3% which equates to about a 1.1% possible variation in velocity. (Change in beta equals change in velocity squared.)

To remove the variations in beta due to changes in the free jet flow, phi was plotted against betabar (Fig. A6). By dividing beta by (PK-PA)/PA, the effect of the changes in flow through the jet are removed. The plot shows only those changes in beta which are due strictly to pitch angle variation. Ideally, all points for each phi should coincide. Some variation is seen at the extreme phi values; however, the betabar scale is over expanded by a factor of two compared to a scale appropriate to the

ability to resolve the measurements, and the differences are therefore unneccessarily exagerated.

Figure A7 clearly shows the strong dependence gamma has on phi. The data points tend to be more closely grouped in the -2 to +2 deg. range with the lower velocity points slightly more separated from the higher velocity points. Part of the reason for this difference may be due to pressure errors at the lower jet velocities having a larger relative effect on the accuracy of the data points.

Total pressure at the conical probe (P1) and total pressure at the Kiel probe (PK) should be nearly identical when phi equals zero. One would expect that the plot in Fig. A8 would reflect this, however it does not. It would be expected that P1 and PK would differ with pitch change, accompanied by some movement of the data points away from zero, but the dispersion of the data in this plot is difficult to explain. The general trend is that nearly all points are less than zero, implying that PK is generally higher than P1. This is corroborated by the free jet survey which shows that the Kiel probe was immersed in a slightly higher velocity region than was the conical probe (see Fig. A9). Note that JOHN4 corrects for this difference when calculating the coefficients. Additionally, it is pointed out by Dreon [Ref. 4] that the core of the free jet has a 0.05 degree pitch to it. The combination of a nonuniform velocity profile and

unsteadiness at low flow velocities might explain some of the observed scatter.

A5. RECOMMENDATIONS

The recommendations presented here focus on software and hardware improvements. The recommendations are:

1. Restore the capability to generate surface plots of the X and phi functional relationship with beta and gamma using the "best fit" polynomial and calibration coefficients. This would provide a visual qualitative check of the fit to the calibration data (Figs. A3 and A4).

2. Modify the HP-9830 based program PRBRED to include the computation of beta bar.

3. Create specific plotting programs on the HP-9830 to plot the quantities in Figs. A5 - A8.

4. Repair or service the printer that supports the HP-21MX system. Frequent malfunctions dramatically slowed the execution of HP-21MX programs.

5. Investigate the feasibility of replacing the HP-9830 with an HP-300 system for probe calibration and related work.

APPENDIX B

SOFTWARE

B1. INTRODUCTION

The software consists of three programs; namely, "ACQUIRE," "CALC," and "LOSS." An in-depth knowledge of computer programming is not required to run the programs; however, some knowledge of programming in Hewlett Packard BASIC 5.0 would be required in order to plot results or make corrections to data files. A rudimentary knowledge of computers by the user is presumed. The main references for the programs are Ref. 13 - 17.

The programs were written to be understandable and flexible. To facilitate understanding program flow, emphasis was placed on clear logic rather than sophistication. To this end, subroutines were called from a library to perform all calculations and repetitive operations. In addition to providing for one or two probe surveys, modifications to hardware addresses on the interface bus or changes to scanner channel assignments can be made easily at the beginning of the program.

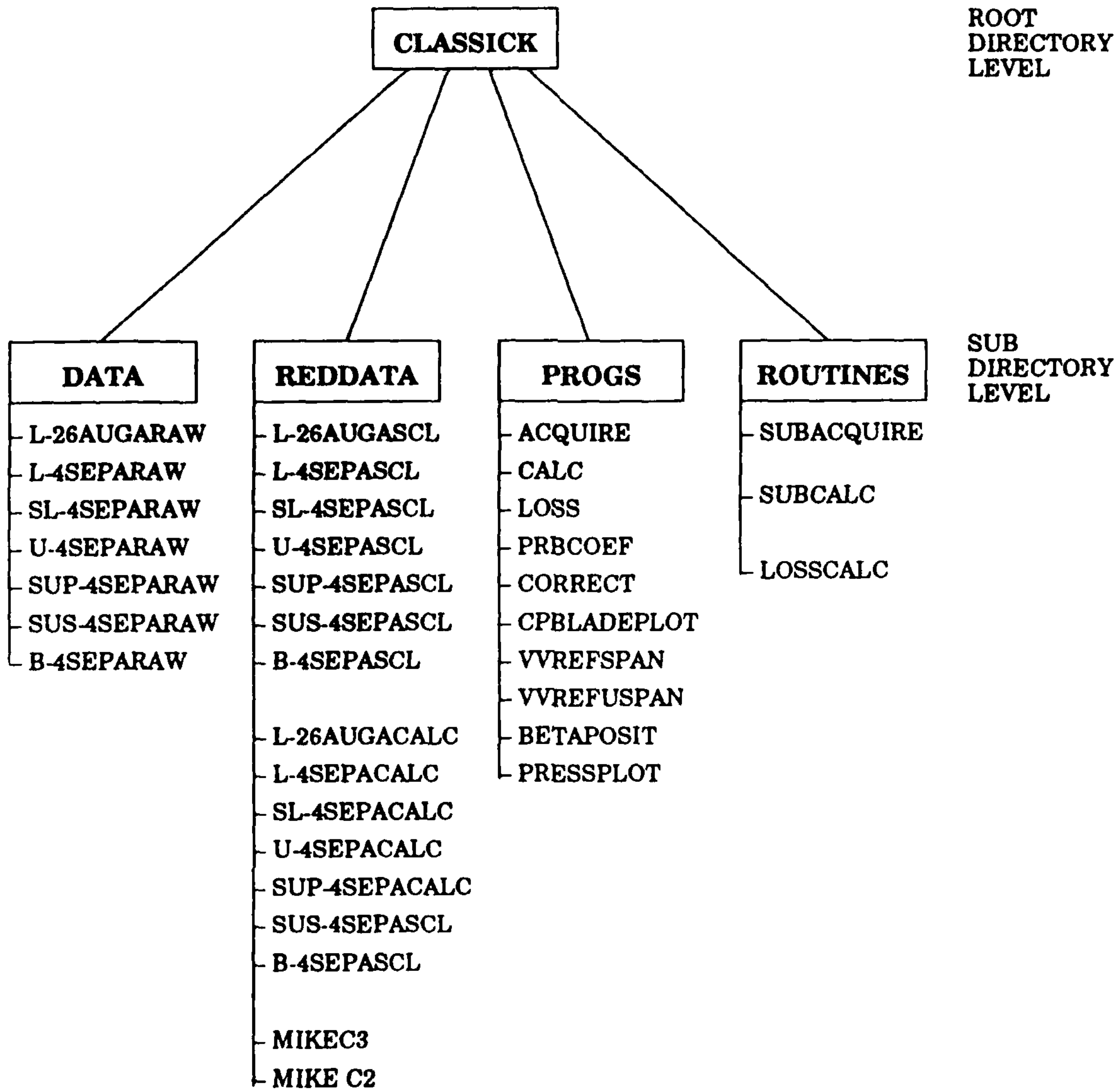
An overview of the file system and program flow is given in sections B2 and B3 respectively, and the step-by-step procedures required to run the programs are given in Section B4, Program Execution. Common errors and recovery steps are addressed in Section B5, and common modifications are discussed in Section B6. Copies of the three main

programs are contained in Section B7 along with examples of the plotting and data file correction programs. Examples of output tables of scaled and reduced data for both detailed blade-to-blade surveys are also contained in this section. Initialization of flexible discs and backing up files to flexible discs is addressed in Section B8. Recommendations to improve the software are presented in Section B9. Finally, for the user, a summary of the steps involved in running the program is given in Section B10.

B2. FILE SYSTEM

Chapter 3 and 10 of Ref. 13 cover mass storage concepts (how the computer's hard disk can be divided up for storage space) and the use of files and directories respectively. The current directory and file system is shown in Fig. B1. Four subdirectories were created under CLASSICK in the root directory. The sub directory DATA contains all the digital voltmeter (DVM) readings during the survey. Scaled data, or raw data that has been scaled in engineering units, e.g., pressure, degrees, etc., are stored in REDDATA, along with the scaled data reduced to useful calculated quantities. The probe calibration coefficients are also stored in REDDATA. The main and ancillary programs are contained under PROGS. ROUTINES contains all the subroutines called by the main programs.

When conducting a probe survey, files need to be created to store the data. Data can be collected from blade-to-blade or span-wise probe surveys or from a scan of



PREFIX

L	Lower Traverse
SL	Span Lower Traverse
U	Upper Traverse
SUP	Span Upper Traverse Pressure
SUS	Span Upper Traverse Suction
B	Blade

SUFFIX

RAW	Raw Voltage Readings
SCL	Scaled
CALC	Calculated (reduced)

Figure B1. File System

the instrumented blade surface pressures. For each survey, raw data, scaled data and reduced data files are created as the user progresses through the programs. The file names are arbitrary but should be descriptive in the interests of identification and kept to a maximum of twelve characters. The file names in this report consisted of a prefix to designate the survey type, followed by the date, run and data type. The prefix and suffix meanings are given in Fig. B1. As an example, the raw data acquired from the lower traverse blade-to-blade probe survey which was conducted on 4 Sept., was named "L-4SEPARAW." If, for some reason, this survey were repeated the same day and the previous survey results were saved, the new file would be named "L-4SEPBRAW." The user should define the file names for the proposed surveys before executing the program.

B3. PROGRAM FLOW

The program flow from the user's perspective is shown in Fig. B2(a)-(d). The figures show, verbatim, the prompts the user will see on the screen and the effects that options will have when selected. The selection of options will be addressed in the following section.

B4. PROGRAM EXECUTION

In this section the procedures to power up the system and run the programs will be spelled out. (A summary of the steps for the user to run the programs is given in Section B10.) The intent here is to provide the user with

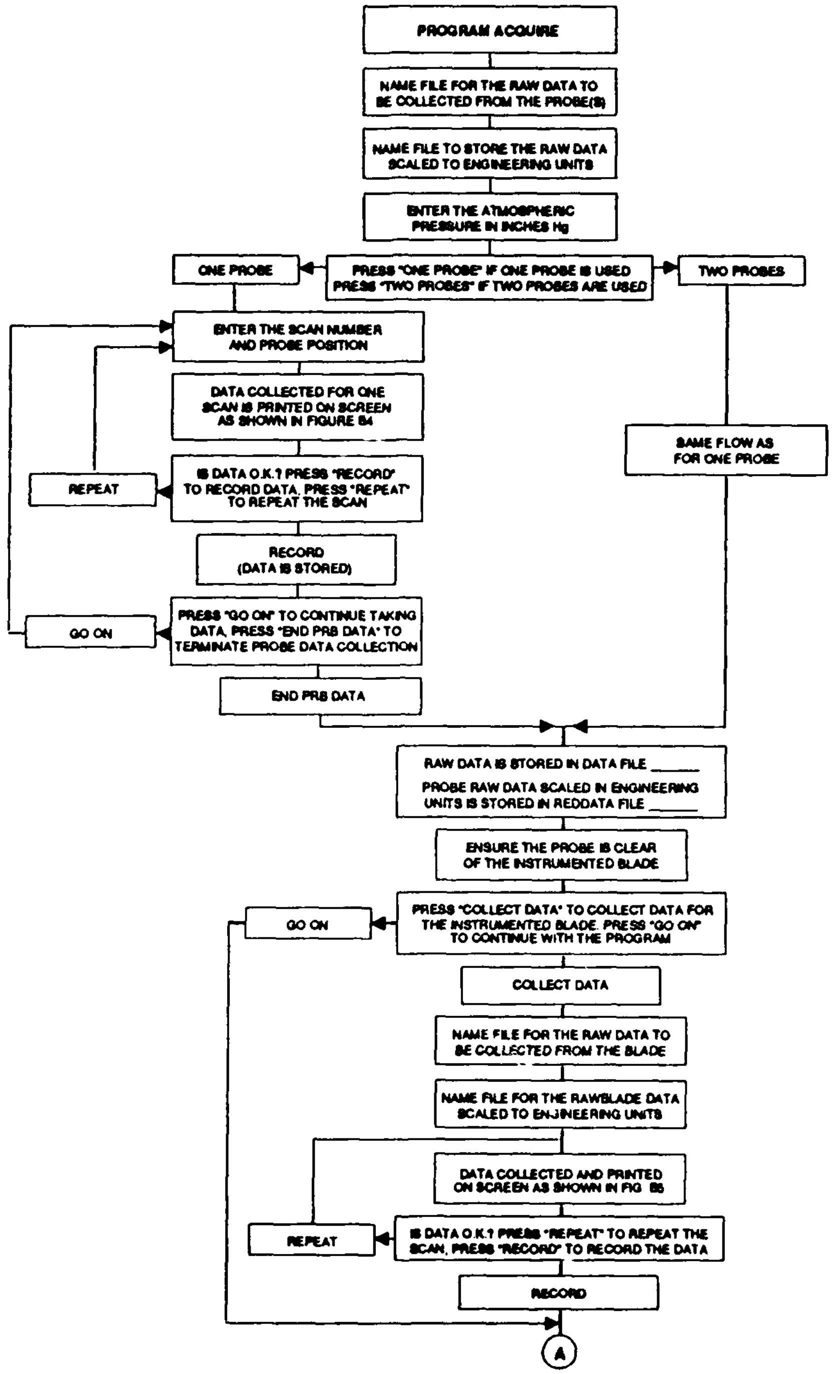


Figure B2(a) Program Flow Chart - ACQUIRE

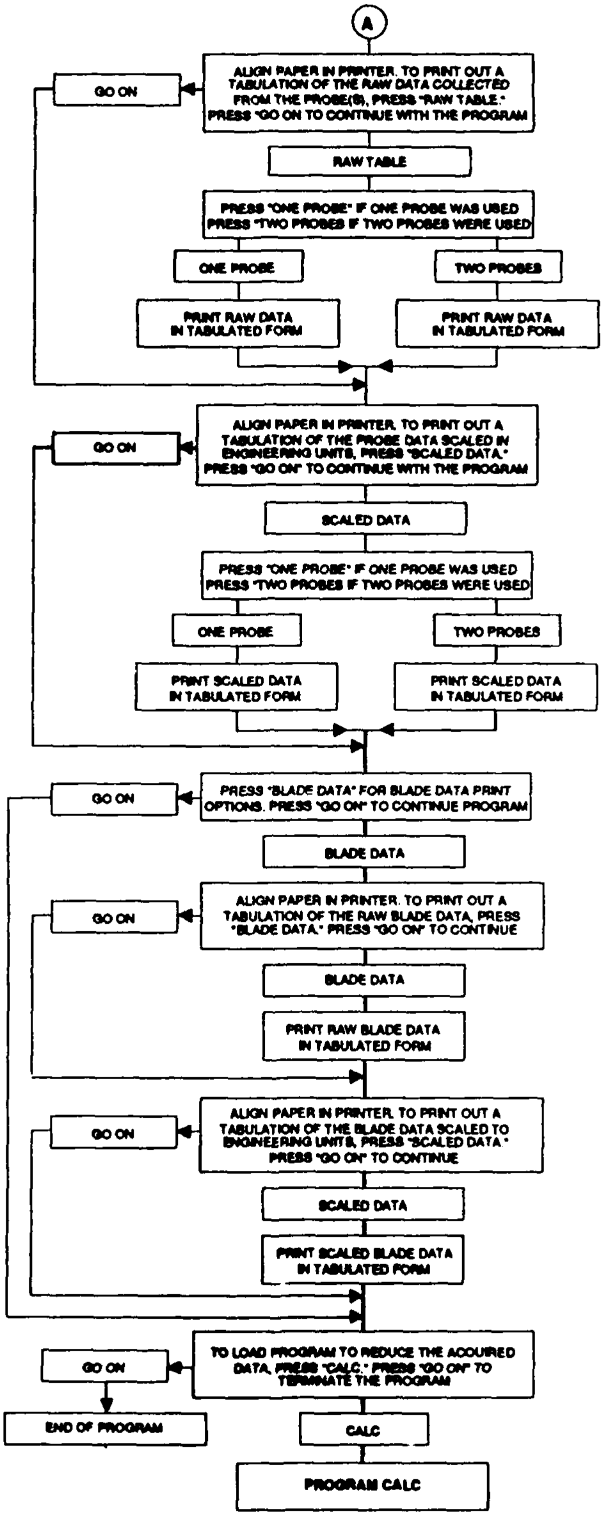


Figure B2(b) Program Flow Chart - ACQUIRE (cont.)

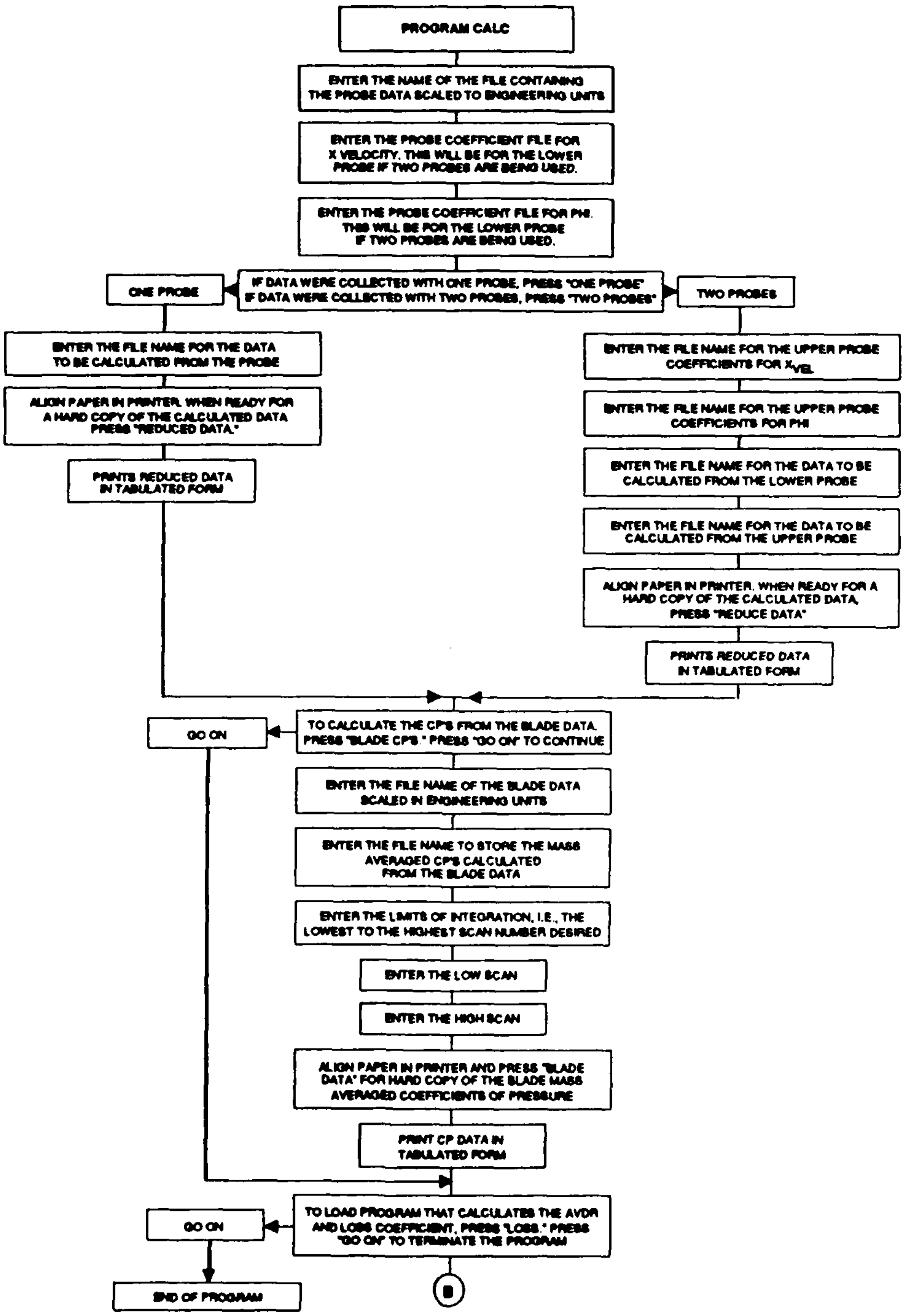


Figure B2(c) Program Flow Chart - CALC

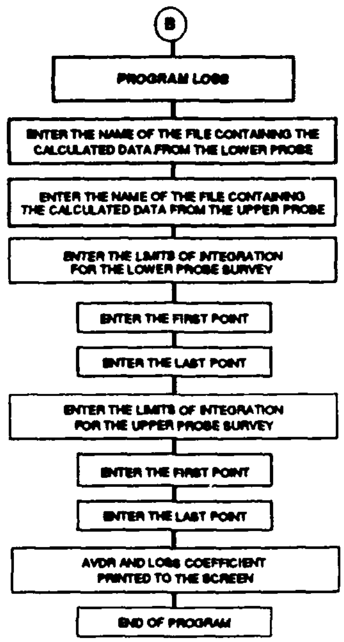


Figure B2(d) Program Flow Chart - LOSS

the necessary information to acquire and reduce the data in order to obtain the loss coefficient from a set of probe surveys. The program flow chart should be referred to as the program steps are briefly explained.

1. Turn on the DVM, scanner and Scanivalve controller. The computer will not boot-up unless the DVM or scanner is on, however, all of these components must be on before starting the survey.

2. Turn the disk drive on and wait for the self test to complete (two amber lights below the flex disc access extinguish).

3. Turn on the computer, monitor and printer. The printer power switch is located behind the unit.

4. The system will boot up the HP BASIC 5.0 resident on the hard disc and go through a series of self tests. In less than a minute, the Hewlett Packard copywrite statements will appear on the monitor. Soft key labels appear along the bottom of the screen; these correspond to the top row of keys on the keyboard labeled f1 - f8. The key board and an example of what the soft key labels ok like for step 12 is shown in Fig. B3.

5. Press f5 corresponding to the soft key label LOAD.

6. Type /CLASSICK/PROGS/ACQUIRE between the quotation marks. Press RETURN. This establishes the path from

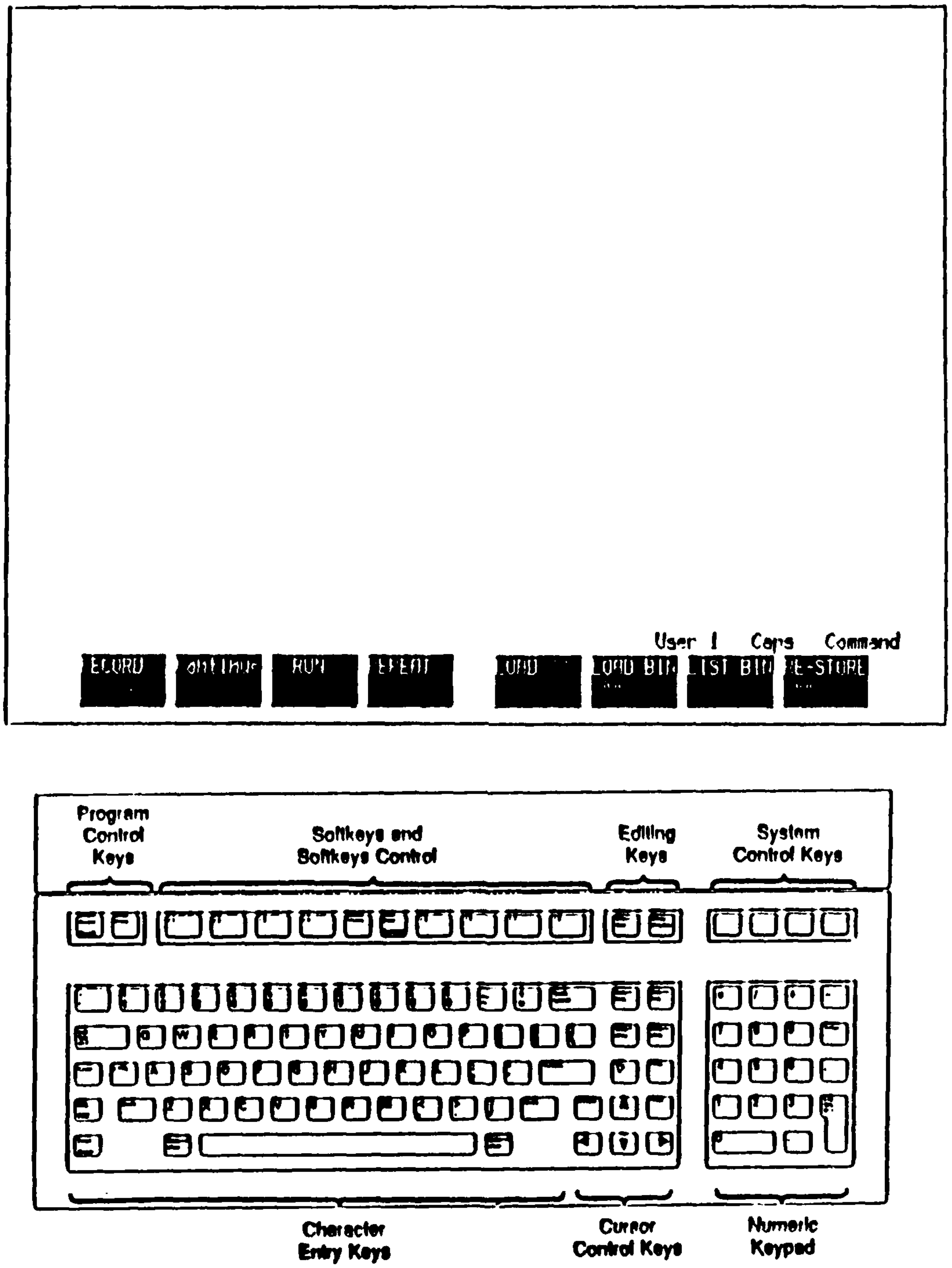


Figure B3. Keyboard and Softkey Labels

the root directory where the CLASSICK directory is located to the file ACQUIRE via the subdirectory PROGS. An alternate way of doing this would be to type in at the blinking cursor the word LOAD followed by "/CLASSICK/PROGS/ACQUIRE." Press RETURN.

7. Press f3 corresponding to the soft key label RUN. The first prompt in the ACQUIRE program will appear. From the program flow chart, it can be determined that the prompt will read "NAME FILE FOR THE RAW DATA TO BE COLLECTED FROM THE PROBE(S)." The file name is typed in directly without quotation marks, e.g., L-2SEPARAW. Press ENTER.

8. At the next prompt, type in the scaled data file, e.g., L-4SEPASCL. Press RETURN.

9. Type in the atmospheric pressure in inches of mercury, e.g., 29.92. Press RETURN. In the program this defines the variable Pbaro as equal to 29.92. This will normally be constant throughout the duration of a survey, however, in the rare event of a weather front passing through, the barometric pressure can change during the survey. If the change is significant, the variable Pbaro can be redefined while the program is running by performing the following steps:

a. Press the STOP key next to key f1.

b. Type Pbaro 30.00 to change from 29.92 to 30.00.

c. Press RETURN.

c. Press f2 corresponding to soft key label CONTINUE.

10. Once step 9 has been completed, the one or two probe option prompt appears, and the soft key labels EDIT and SCRATCH corresponding to keys f1 and f4 respectively are replaced by ONE PROBE and TWO PROBES. Press the appropriate key. Note that the only soft keys the user will press during normal program execution will be those corresponding to keys f1 and f4. It will be assumed in the following steps that the one probe option was used - the only difference in procedure will be an additional position that the user must enter for the second probe.

11. The scan number and position are typed in and separated by a comma, e.g., 43, 2.55. Press RETURN. The scan number can be up to four characters and the position, seven characters - four to the left and two to the right of a decimal.

12. <u>The scan begins after RETURN is pressed for step 11</u>. All the data for the scan will print to the screen for the user to evaluate. An example of the screen presentation is given in Fig. B4. If the data is unsatisfactory, press f4 corresponding to soft key

```
*****************************************************************
SCAN NUMBER 2
PROBE POSITION 200
PORT          VOLTAGE       GUAGE PRESSURE(INCHES H2o)
 1             4.000E-07             4.000E-03
 2             9.052E-04             9.048E+00
 3             1.182E-03             1.182E+01
 4            -6.170E-04            -6.174E+00
 5             5.254E-04             5.250E+00
 6            -6.560E-05            -6.600E-01
 7            -6.380E-05            -6.420E-01
 8            -3.060E-05            -3.100E-01
 9            -1.106E-04            -1.110E+00
10             1.016E-03             1.016E+01
11            -6.790E-04            -6.794E+00
12             4.000E-07             0.000E+00
13            -2.600E-06            -3.000E-02
14             6.000E-07             2.000E-03
***********************************************************
YAW CHAN READING                   .0023624
YAW (DEGREES)                      2.3624
TEMP CHAN READING                 -.0012328
TEMPERATURE (DEGREES R)            452.445752
ATMOSPHERIC PRESS (INCHES)         30.00 (Hg)       407.10(H2o)

***************************************************************

IS DATA OK? PRESS "RECORD" TO RECORD DATA, PRESS "REPEAT" TO
REPEAT THE SCAN.

***************************************************************
```

Figure B4. Data Printed on the Screen -
One Probe Scan

label REPEAT. This will return the program to step 11. If the data is satisfactory, press f1 corresponding to soft key label RECORD. The disc drive amber light will flash momentarily as the data is stored on the disk.

13. Press GO ON to continue taking more data. This will return the program to step 11 again and the cycle repeats until the survey is terminated by pressing END PRB DATA.

14. A statement appears informing the user what file names the raw and scaled data files are under. This is just a reminder and requires no action.

15. The next statement is a reminder to clear the probe away from the instrumented blade before collecting a blade surface pressure distribution.

16. Options appear to either collect the blade data or by-pass this operation and go on to the print options.

17. The collect option requires file names for the raw and scaled data. Type the names as was done in steps 7 and 8.

18. The scan begins after RETURN is pressed for step 17. The blade data will be printed on the screen. As in step 12, the scan can be repeated if the data is unsatisfactory. An example of the screen presentation

is given in Fig. B5. Similarly, the data is stored when RECORD is pressed.

19. After recording blade data, there follows a series of print options for the stored probe and blade data. The steps are readily apparent from the program flow chart. Note that this is the only time to obtain a hard copy of the raw and scaled probe and blade data. <u>Currently a program does not exist to print the data from an arbitrary file in the tabulated format produced by the ACQUIRE program.</u>

20. The last step in program "ACQUIRE" is the option of terminating the program by pressing GO ON or loading the reduction program "CALC" by pressing CALC. If the data collected is to be reduced at a later time, then GO ON is the correct choice. Later, when the user is ready to reduce the data, program "CALC" is executed by following steps 5 and 6 except type /CLASSICK/PROGS/CALC; press RETURN, then press soft key RUN.

21. Once "CALC" is executed, the first prompt that appears is "ENTER THE NAME OF THE FILE CONTAINING THE PROBE DATA SCALED TO ENGINEERING UNITS." This is the scaled data file produced during the execution of "ACQUIRE." A new file is not being created at this time - the entry allows "CALC" to reduce the data in

SCAN NUMBER 11

PORT	VOLTAGE	GUAGE PRESS(INCHES H2o)
1	1.000E-06	1.000E-02
2	9.008E-04	8.998E+00
3	1.206E-03	1.205E+01
4	-3.380E-04	-3.390E+00
5	-1.048E-04	-1.058E+00
6	2.380E-05	2.280E-01
7	8.000E-05	7.900E-01
8	9.780E-05	9.680E-01
9	8.300E-05	8.200E-01
10	6.240E-05	6.140E-01
11	8.260E-05	8.160E-01
12	7.260E-05	7.160E-01
13	8.500E-05	8.400E-01
14	1.712E-04	1.702E+00
15	2.334E-04	2.324E+00
16	2.144E-04	2.134E+00
17	1.334E-04	1.324E+00
18	1.728E-04	1.718E+00
19	2.270E-04	2.260E+00
20	3.804E-04	3.794E+00
21	4.674E-04	4.664E+00
22	6.896E-04	6.886E+00
23	-1.709E-03	-1.710E+01
24	-3.333E-03	-3.334E+01
25	-3.202E-03	-3.203E+01
26	-2.779E-03	-2.780E+01
SAMPLE EXCEEDED MAXIMUN DEVIATION ALLOWED-SAMPLE RETAKEN		
27	-2.068E-03	-2.069E+01
28	-1.631E-03	-1.632E+01
29	-1.411E-03	-1.412E+01
30	-1.238E-03	-1.239E+01
31	-1.043E-03	-1.044E+01
32	-8.212E-04	-8.222E+00
33	-6.908E-04	-6.918E+00
34	-5.584E-04	-5.594E+00
35	-4.712E-04	-4.722E+00
36	-4.158E-04	-4.168E+00
37	-3.784E-04	-3.794E+00
38	-3.608E-04	-3.618E+00
39	-3.350E-04	-3.360E+00
40	-3.232E-04	-3.242E+00
41	-3.068E-04	-3.078E+00
42	-2.922E-04	-2.932E+00
43	3.334E-04	3.324E+00
44	-9.170E-04	-9.180E+00
45	-3.214E-04	-3.224E+00
46	1.446E-04	1.436E+00
47	9.420E-05	9.320E-01
48	-2.656E-04	-2.666E+00

****

IS DATA OK? PRESS 'REPEAT' TO REPEAT THE SCAN, PRESS 'RECORD' TO RECORD THE DATA.

****

Figure B5. Data Printed on the Screen - Instrumented Blade Scan

the scaled data file to useful engineering quantities. Type the file name, e.g., L-4SEPASCL. Press RETURN.

22. The next two prompts are to allow "CALC" access to the probe calibration coefficient file - one for X and one for Phi. For this study the X file was MIKEC3 and the Phi file was MIKEC2. Type these file names in at the prompt followed by RETURN.

23. The one or two probe option appears next. The difference between the two choices, is in the prompts displayed. Two probes require two additional calibration coefficient files to be accessed - hence the prompts for the upper probe coefficient file for X and Phi.

24. The prompt "ENTER THE FILE NAME FOR THE DATA TO BE CALCULATED FROM THE PROBE," requires the user to create a new file for the data about to be reduced from the scaled data file. Type the file name, e.g., L-4SEPACALC. Press RETURN. Note that for the two-probe survey, an additional file must be created for the second probe, even though only one scaled data file was created in "ACQUIRE" for either a one or two-probe survey.

25. The next prompt will remain on the screen until the REDUCED DATA soft key is pressed. It is assumed that the "CALC" program would not be executed unless a

hard copy of the reduced data were desired, hence, no other options are available.

26. The option to calculate the mass averaged coefficient of pressure from the instrumented blade data appears next. Pressing GO ON bypasses this calculation. Pressing BLADE CP'S prompts the user for additional information.

27. As in step 21, type in the scaled blade data file, e.g., B-4SEPASCL. Press RETURN.

28. As in step 24, type in the name of the file to be created for the blade C_p's, e.g., B-4SEPACALC. Press RETURN.

29. The next prompt requires the user to supply the limits of integration for the probe survey file entered in at the beginning of "CALC" e.g., L-4SEPASCL. This file contains data for the blade-to-blade survey upstream at midspan, which is the inlet condition to the instrumented blade. (The taps are located at midspan.) Quantities obtained from the blade-to-blade scaled file and reduced file are mass averaged for the C_p calculation as shown in Table I. The limits of integration are determined by noting what the beginning and ending scan numbers are. In the case of L-4SEPASCL, the first scan was 1 and the last scan, 31. For "ENTER THE LOW SCAN", type 1. Press RETURN. For

"ENTER THE HIGH SCAN", type 31. Press RETURN. Note that it is not the position that is entered, but the scan number corresponding to the position that is entered. Additionally, the integration limits can be over a shorter interval than the entire length of the survey if desired.

30. The prompt to print the blade C_p's appears once the computer completes the C_p calculations.

31. The final prompt in "CALC" allows the user to terminate the program by pressing GO ON or to execute program "LOSS" by pressing LOSS. To calculate the AVDR and loss coefficient, requires an upper and a lower blade-to-blade survey. The execution of "LOSS" at this point would not be appropriate unless the user has a reduced file for an upper and lower blade-to-blade probe survey.

32. If program "LOSS" was not executed by pressing the LOSS soft key in step 31, then it can be executed by pressing the LOAD soft key and typing /CLASSICK/PROGS/LOSS between the quotation marks and pressing RETURN. Press the RUN soft key.

The static pressure rise coefficient, AVDR and loss coefficient are calculated from quantities contained in the reduced files of the upper and lower blade-to-blade surveys as shown in Table I. The

entries for the prompts provide the program access to the reduced data files.

33. The prompt "ENTER THE NAME OF THE FILE CONTAINING THE CALCULATED DATA FROM THE LOWER PROBE" requires the user to enter the file name for the lower probe blade-to-blade survey data that was reduced in "CALC" e.g., L-4SEPACALC. Press RETURN.

34. The next prompt pertains to the upper probe blade-to-blade survey reduced data e.g., U-4SEPACALC. Press RETURN.

35. Integration limits for the lower probe blade-to-blade survey are requested next. As noted in step 29, it is the scan number corresponding to the lower limit of the integration interval that is entered for "ENTER THE FIRST POINT." Likewise, the scan number for the upper limit of the integration interval is entered for "ENTER THE LAST POINT."

36. Limits of integration, in terms of scan number, are requested again for the upper probe blade-to-blade survey.

Note that the upper and lower integrations must be the same, exact, integral number of blade spaces (usually one), but the number of scans to cover the same distance will probably be different. It is vitally important to ensure that correct scan numbers,

match desired integration limits when the integration interval is something other than the beginning and ending of a blade-to-blade survey.

37. The calculations are performed and the static pressure rise coefficient, AVDR and loss coefficient are printed on the screen; the program then terminates.

B5. COMMON ERRORS AND RECOVERY STEPS

B5.1 Introduction

Common errors germane to the program execution are outlined in this section. Errors for each program are covered rather than broad categories of errors. Specific recovery steps are given which, in some cases, require knowledge of the program structure. Since probe surveys are time consuming, it behooves the investigator to be familiar with the program. A mistake in many cases may be rectified by stopping the program, then continuing at a specific line in the program. To this end, a copy of the three main programs should be available during a survey. A listing of the programs may be obtained by following the steps outlined in Section B6. In those cases where a specific recovery step cannot be made, the user is referred to Ref. 13-17. A complete listing and description of system errors can be found in Ref. 16.

While not specifically an error associated with program execution, the new user may become lost in the directory. The Mass Storage Is or MSI command (addressed in Ref. 13),

in conjunction with a path name, allows the user to move through the directory levels. The command MSI"/" places the system in the root directory while the command MSI"/CLASSICK", places the system in the CLASSICK directory which is subordinate to the root directory. Executing any of the three main programs by following the steps in Section B4 will initially place the system in the PROGS subdirectory. As the program runs, the subdirectory will change to facilitate entry of the various file names. In all cases when the programs have terminated, the system is in the REDDATA subdirectory. The program can be repeated even from this subdirectory by pressing RUN. However, if the user decides to move somewhere else in the directory, the MSI command and path name must be used. As an example, upon "CALC" termination it is desired to execute "ACQUIRE." The command MSI "/CLASSICK/PROGS" puts the system in the PROGS subdirectory. "ACQUIRE" can then be loaded from the subdirectory PROGS by pressing LOAD and typing ACQUIRE between the quotation marks.

Alternatively, "ACQUIRE" could have been loaded from subdirectory REDDATA by pressing LOAD followed by typing "/CLASSICK/PROGS/ACQUIRE".

B5.2 ACQUIRE

1. Errors Involving File Names

These errors will most likely be the result of either attempting to enter a file name which exceeds twelve characters or entering an undesired file name. If a

system error is returned while attempting to enter a file name and it is suspected that the name exceeded twelve characters, reenter the file name using twelve characters or less. Refer to Ref. 16 for other system errors.

Undesired file names which have been entered into the system i.e., the file was created, can be handled in different ways. Assuming no data had been collected, the program could be aborted, the undesired file name purged and the program reexecuted. The steps for this would be:

a. Press STOP (This is a labeled key on the top row).

b. Type MSI "/CLASSICK/SUBDIRECTORY NAME" (subdirectory name is either DATA for rawdata files or REDDATA for scaled or reduced data files).

c. RETURN

d. Type PURGE "UNDESIRED FILE NAME" (include quotation marks).

e. RETURN

f. Press LOAD

g. Type /CLASSICK/PROGS/ACQUIRE between quotation marks.

h. RETURN

i. Press RUN

Alternatively, the program could be run with the undesired file name and the name changed after terminating "ACQUIRE." The steps for this would involve writing a short program.

2. Incorrect Atmospheric Pressure Entry

The required steps are as follows:

a. Press STOP

b. Type Pbaro = CORRECT VALUE

c. RETURN

d. Press CONTINUE

3. Incorrect Probe Option Selected

The required steps are as follows:

a. Press STOP

b. Type CONT 145

[Line 145 is the line number which the program would have to return to in order to generate the probe option prompt again.]

c. RETURN

4. Incorrect Scan Number or Probe Position Entered

Upon pressing RECORD, an error statement will be returned if the scan number was entered out of sequence. This will prevent the data from being stored. Take the following steps:

a. Press STOP

b. Type CONT 162 for a one probe survey

c. Type CONT 160 for a two probe survey

[These are the line numbers in the program that return the prompt for entering the scan number and position.]

d. RETURN

An incorrect position entry will not return an error statement. A correction to position can be done using a version of program "correct" after completion of the survey.

5. Premature Termination of Data Collection

If END PRB DATA was mistakenly pressed, the ability to continue with probe data collection can be regained by these steps:

a. Press STOP

b. Type CONT 162 for a one probe survey

c. Type CONT 160 for a two probe survey

d. RETURN

6. By-passed Collecting Blade Data Mistakenly

The required steps are as follows:

a. Press STOP

b. Type CONT 357. [This line number returns the blade data collection option prompt.]

c. RETURN

7. By-passed Hard Copy Print Options Mistakenly

The required steps are as follows:

a. Press STOP

b. Type CONT 408. [Line 408 is the beginning of the hard copy option prompts.]

c. RETURN

B5.3 CALC

1. Incorrect File Entered

The "CALC" program will reduce any scaled data file obtained from "ACQUIRE." If an undesired file name was entered, abort the program then reexecute it using the following steps:

a. Press STOP

b. Press RUN

2. Incorrect Probe Coefficient File Entered

The required steps are as follows:

a. Press STOP

b. Type CONT 144. [Line 144 will return the prompt for entering the X velocity coefficient file.]

c. RETURN

3. Incorrect Probe Option Selected

The required steps are as follows:

a. Press STOP

b. Type CONT 200 [Line 200 returns the probe option prompt.]

c. RETURN

4. Incorrect Reduced Data File Name Entered

"CALC" is short enough to allow termination and reexecution of the program in order to enter the correct desired file name for the reduced data. The steps to do this are:

a. Press STOP

b. Press RUN

The undesired file name can be purged from the REDDATA subdirectory by following the steps in paragraph "1" of Section B5.2. If "CALC" is to be executed after the purge operation, press LOAD and type /CLASSICK/PROGS/CALC between the quotation marks. Press RETURN followed by pressing RUN.

5. By-passed Blade C_p Calculations Mistakenly

The required steps are as follows:

a. Press STOP

b. Type CONT 736. [Line 736 returns the blade C_p calculation option.]

c. RETURN

6. Incorrect Limits of Integration Entered

Unless the limits entered are non existent, no error will be returned--only erroneous data if the limits are wrong. If the C_p values do not look correct, the calculation can be repeated if the integration limits are suspected to be in error. Perform the following:

a. Press STOP

b. Type CONT 736. [This will return the blade C_p calculation option. A new reduced blade data file name will have to be entered since the previous file name contains the suspect C_p reduced data. This suspect file can be purged following the steps in paragraph 1, Section B5.2.]

c. RETURN

B5.4 LOSS

"LOSS" is a short program; any errors in entering the prompted entries can be handled by terminating the program and starting again. The steps are:

a. Press STOP

b. Press RUN

B6. MODIFICATIONS

B6.1 Introduction

The programs were written to accomodate changes that might be expected to occur in the equipment set-up of the cascade facility. Variables defining scanner channel assignments, HP-IB equipment addresses and other variables that might change as the investigations are modified were placed at the beginning of the program. Thus, all such changes are made in one section of the code. Those variables embedded in the program such as temperature, yaw and position are cited by line number to allow modifications to be made in the way they are evaluated. Array elements were redefined when necessary. Changes to array elements require familiarization with the program structure. All changes should be followed up with a revalidation of the modified code prior to acquiring new survey data.

Program modifications are made and their effects evaluated best by examining a hard copy of the program.

Obtain a copy of any program in the PROGS subdirectory by performing the following steps:

a. Type MSI"/CLASSICK/PROGS"

b. RETURN

c. Type CAT [This will list all the programs or files in the PROGS subdirectory. After identifying the desired program, proceed with the next step.]

d. Type PRINTER IS 701 [Output is now directed to the printer.]

e. RETURN

f. LOAD "DESIRED PROGRAM"

g. RETURN

h. Type LIST

i. RETURN [The program will now be printed.]

Note that after the program is printed, retu: the system to print on the screen by typing PRINTER IS 1, followed by RETURN.

Once the changes have been identified, refer to Chapter 11, of Ref. 13 to edit and store the modified program.

B6.2 Common Changes

In "ACQUIRE" the common variables that might be changed are listed in the front of the program along with a plain langauge description of what the variable represents. It is assumed the user will understand the rudiments of the acquisition system prior to making any variable changes.

B6.3 Temperature, Yaw and Position Changes

The variable Temp on line 245 of "ACQUIRE" is defined by an equation that represents the characteristics of the iron-constantan thermocouple used in the present work. This equation will change if the thermocouple changes. Edit this line with appropriate changes to account for a thermocouple change.

Referencing the yaw angle to a precisely known horizontal or vertical axis as outlined in Appendix C requires a correction to the yaw transducer output. This correction can be made in "ACQUIRE" by modifying line 240 for a one probe survey or lines 207 and 212 for a two probe survey. An alternative to this would be to modify "CALC". Change line 626 for a one probe survey; change lines 359 and 491 for a two probe survey.

Incorporating the use of linear potentiometers for probe position read-out is a more extensive modification to "ACQUIRE" which will be briefly summarized for a one probe survey. A scanner channel for the potentiometer transducer must be assigned and this channel defined by a variable name. The variable must be included in the COM statement on line 169 and in line 754 of the subprogram "Readdvm". A CALL statement similar to that listed for the Yaw and Temp channel readings on lines 238 and 242, is required. A statement allowing the transducer channel to be read by the DVM must be included in the IF-ELSE structure of "Readdvm". Array elements presently defining

probe position must be modified if necessary and traced through "CALC".

B6.4 Array Elements Changes

In "ACQUIRE," Scanivalve port readings, in addition to other quantities are assigned an array element. A change in an array element assignment may require a change in the formatted print statements and headings. Additionally, since array elements are redefined during the execution of the three main programs, a trace through those programs is necessary to ensure that any changes in array element assignments are consistent.

B.7 PROGRAMS AND DATA

A complete listing of the program and data files is given in the Table of Contents for Appendix B. The three main programs have been previously explained. The listed subprograms are called by the main programs from the ROUTINES subdirectory during execution. The plot programs are specifically those used to plot some of the data in the present study. The following is a list of the figures corresponding to the plot program written for it:

Program	Figure
PREFPQREF	18
BETAPOSIT	19
VVREFSPAN	8
VVREFUSPAN	11
CPBLADEPLOT	23

Plots are printed to the printer by pressing DUMP GRAPHICS. Samples of the programs to correct erroneous data points or to rereference the probe-displacement are included. "CORRECT A" (Section B7.12) was used to extrapolate the recorded data to add an additional scan. This was done to enable data to be integrated over exactly one blade space. The artificially generated scan does not appear in Table B4 but does appear in Table B5. "CORRECT B" (Section B7.13) provided the means to correct an incorrect value of probe position entered during a scan. The corrected value then appears in Table B5. "CORRECT C" (Section B7.14) was used to rereference displacement values of file SUS-4SEPASCL (example not included) to make the midspan position equal to zero.

The probe calibration coefficients were stored in a file using "PRBCOEF" (Section B7.15) with actual coefficients in the DATA statement in lieu of those in the example. Note that the DATA statement must contain 36 entries to be consistent with the way the file is used in the program "CALC."

The remainder of the tables have been previously addressed.

B7.1 Acquisition Program ACQUIRE

```
10    !PROGRAM ACQUIRE
11    !THIS PROGRAM ACQUIRES DATA FROM 5-HOLE PROBE SURVEYS AND PRESSURE
12    !DISTRIBUTION FROM AN INSTRUMENTED BLADE. SEE CLASSICK M.S. THESIS
13    !SEPT 89 FOR PROGRAM DESCRIPTION AND DETAILS.
52    !******************* DIMENSION ARRAYS *****************************
53    OPTION BASE 1            !BASE OF ARRAY WILL BE ONE INSEAD OF ZERO
54    DIM Rawdat(1,106)        !THIS ARRAY WILL ACCOMODATE BOTH 48 PORT
55                             !SCANIVALVES AND 10 CHANNELS FROM THE SCANNER
                               !FOR A TOTAL OF 106 COLUMNS OF DATA.
56    DIM Scaled(1,106)        !ARRAY USED IN PRINTING PROBE & CASCADE PRSSURES
57                             !TO SCREEN
59    DIM Prntdata(1,48)       !ARRAY USED IN PRINTING BLADE PRESSURES TO SCREEN
60    DIM Prntdatb(1,48)
61    MAT Prntdata= (0)        !INITIALLY FILLS ARRAY WITH ZEROS-IF ENTIRE ARRAY
62                             !IS NOT FILLED WITH DATA, THEN REMAINDER OF ARRAY
63                             !WILL CONTAIN ZEROS.
65    MAT Prntdatb= (0)
66    !******************* VARIABLES ***********************************
67    Dport=1                  !DESIRED PORT. IT IS DESIRED THAT THE SCANIVALVE
68                             !BEGIN AT PORT 1.
70    Hport=14                 !HIGH PORT. LAST PORT ON THE SCANIVALVE THAT IS
71                             !OF INTEREST.
73    Dporta=1                 !SAME AS ABOVE EXCEPT IT PERTAINS TO SCANIVALVE
74                             !RESERVED FOR INSTRUMENTED BLADE SURVEY.
76    Hporta=48                !ALL PORT USED ON THE BLADE SURVEY
77    Dportb=1                 !IN TWO PROBE SURVEYS, MORE PORTS ARE USED-THE
78                             !DESIRED PORT IS STILL 1.
80    Hportb=19                !LAST PORT OF INTEREST FOR TWO-PROBE SURVEYS.
81    Scntempchn=10            !SCANNER CHANNEL ASSIGNED TO THERMOCOUPLE
82    Scnyawchn=24             ! "      "      "       " YAW TRANSDUCER.
83    Scnyawchnl=24            ! "      "      "       " LOWER PROBE YAW
84                             !TRANSDUCER FOR TWO-PROBE SURVEYS.
86    Scnyawchnu=21   17        SCANNER CHANNEL ASSIGNED TO UPPER PROBE YAW
87                             !TRANSDUCER FOR TWO-PROBE SURVEYS.
89    Scnva=1                  !SCANIVALVE USED FOR INSTRUMENTED BLADE.
90    Scnvb=2                  ! "          "   " PROBE & CASCADE PRESSURES.
91    Scn=709                  !SCANNER BUS ADDRESS
92    Svc=707                  !SCANIVALVE CONTROLLER BUS ADDRESS (H6-78K)
93    Dvm=722                  !DIGITAL VOLTMETER BUS ADDRESS
94    Scnrdsvc=1               !SCANNER CHANNEL ASSIGNED TO READ SCANIVALVE
95                             !CONTROLLER (SCANIVALVE READ IS THE ONE FOR
96                             !PROBE AND CASCADE PRESSURES.)
98    Scnrdsvca=0              !SAME AS ABOVE EXCEPT THE SCANIVALVE READ IS FOR
99                             !THE INSTRUMENTED BLADE PRESSURES
101   Scnrdsvcb=1              !SAME AS ABOVE EXCEPT SCANIVALVE READ IS THE
102                            !ONE FOR PROBE & CASCADE PRESSURES WHEN 2-PROBE
103                            !OPTION IS SELECTED.
105   Scnstpsvca=40            !SCANNER CHANNEL ASSIGNED TO STEP SCANIVALVE A
106   Scnstpsvcb=41            ! "      "      "       "  "   "        B
107   Scnhmsvca=45             !SCANNER CHANNEL ASSIGNED TO HOME SCANIVALVE A
108   Scnhmsvcb=46             ! "      "      "       "  "   "        B
109   Maxdif=.000050           !ERROR TRAP FOR SPURIOUS DVM READINGS.
110   Prnter=701               !BUS ADDRESS FOR PRINTER
111   Scren=1                  !BUS ADDRESS FOR MONITOR
112   LOADSUB ALL FROM "/CLASSICK/ROUTINES/SUBACQUIRE"
113   MASS STORAGE IS "/CLASSICK/DATA"  !ALLOWS RAW DATA FILE NAME TO BE ENTERED
114                                     !AT THE PROMPT WITHOUT PATHNAME
116   PRINT "*********************************************************"
117   PRINT ""
118   PRINT "NAME FILE FOR THE RAW DATA TO BE COLLECTED FROM THE PROBE(S)"
119   INPUT Rawfile$
122   CREATE BDAT Rawfile$,100,848 !RAWFILE$ IS A STRING VARIABLE ASSIGNED
124                                !THE RAWFILE NAME TO BE ENTERED AT THE PROMPT.
125                                !THIS FILE IS 100 RECORDS (ENOUGH FOR 100 DATA
126                                !POINTS) EACH RECORD CAN CONTAIN 106 REAL
```

```
127                                   !NUMBERS 8X106=848.
128   ASSIGN @Path1 TO Rawfile$     !ASSIGNS A PATH NAME TO THE RAW FILE JUST
129                                   !CREATED FOR ENTER AND OUTPUT STATEMENTS.
130   MASS STORAGE IS "/CLASSICK/REDDATA"
132   PRINT "************************************************************"
133   PRINT ""
134   PRINT "NAME FILE TO STORE THE RAW DATA SCALED TO ENGINEERING UNITS"
135   INPUT Sclfile$
136   CREATE BDAT Sclfile$,100,848
137   ASSIGN @Path2 TO Sclfile$
138   PRINT "************************************************************"
139   PRINT ""
140   PRINT "ENTER THE ATMOSPHERIC PRESURE IN INCHES HG"
141   INPUT Pbaro
142   PRINT ""
143   PRINT "************************************************************"
144   PRINT ""
145   PRINT "PRESS ""ONE PROBE"" IF ONE PROBE IS USED."
146   PRINT "PRESS ""TWO PROBES"" IF TWO PROBES ARE USED."
147   PRINT ""
148   PRINT "************************************************************"
149   PRINT ""
150   ON KEY 1 LABEL "ONE     PROBE" GOTO Numberprbs1  !CODING FOR SOFT KEYS
151   ON KEY 4 LABEL "TWO     PROBES" GOTO Numberprbs2
152 Spin1:     GOTO Spin1                 !KEEPS SOFT KEY LABELS ON SCREEN UNTIL
153                                       !EITHER SOFT KEY IS PRESSED.
154 Numberprbs1:   Noofprbs=1             !NUMBER OF PROBES DETERMINES WHERE TO
155                                       !GO IN THE PROGRAM.
157   GOTO Checknoofprbs
158 Numberprbs2:  Noofprbs=2
159 Checknoofprbs:  IF Noofprbs=2 THEN
160 Start2prbs:  INPUT "ENTER THE SCAN NUMBER, LOWER PROBE  POSITION AND UPPER P
ROBE  POSITION",Scan,Posit1,Positu
161   ELSE
162 Start1prb:INPUT "ENTER THE SCAN NUMBER AND PROBE POSITION",Scan,Posit
163   PRINT ""
164   PRINT "************************************************************"
165   END IF
166   COM /Positvrbls/ Svc,Scn        !COMMON BLOCK VARIABLES USED IN POSITIONING
167                                   !THE SCANIVALVE PORTS.
169   COM /Readvrbls/ Scan,Dvm,Scanvb(1,48),Tempchnrd,Yawchnrd,Scnyawchn,Scntemp
chn,Scnrdsvcb,Scanva(1,48),Scnrdsvca,Noofprbs,Yawchnrdu,Scnrdsvc
170   COM /Readvrbls/ Yawchnrdl,Scnyawchnu,Scnyawchnl,Maxdif
171                                   !ABOVE COMMON BLOCK VARIABLES USED IN
172                                   !OBTAINING DVM READINGS.
174   IF Noofprbs=2 THEN
175     GOTO Read2prbs
176   ELSE
177     GOTO Read1prb
178   END IF
179 Read2prbs:PRINT "SCAN NUMBER";Scan
180   PRINT "LOWER PROBE POSITION";Posit1
181   PRINT "UPPER PROBE POSITION";Positu
182   PRINT "PORT         VOLTAGE              GAUGE PRESS(INCHES H2o) "
183   MAT Scanvb= (0)
184   FOR Db=Oportb TO Hportb
185     CALL Scnvportposit(Scnvb,Db,Scnhmsvcb,Scnstpsvcb)   !CALLS SUBROUTINE
186                            !TO POSITION SCANIVALVE PORTS. INITIALLY IT WILL
187                            !POSITION SCNIVALVE TO PORT 1.
189     CALL Readdvm(Db,Scnrdsvcb)            !CALLS SUBROUTINE TO READ THE
190                                           !THE SCANIVALVE PORT READINGS ON
191                                           !THE DVM.
193     Prntdatb(1,1)=Scanvb(1,1)*10000       !CONVERTS DVM READINGS TO PRESSURE
194                                           !VALUES.
196   IF Db>1 THEN Prntdatb(1,Db)=Scanvb(1,Db)*10000-Prntdatb(1,1)  !ALLOWS
197                                            !PORT 1 READING TO BE SUBTRACTED
```

```
198                                                        !FROM OTHER READINGS.
200   PRINT USING "DD,10X,MD.3DE,10X,MD.3DE";Db,Scanvb(1,Db),Prntdatb(1,Db)
201   NEXT Db
202   CALL Readdvm(Db,Scnyawchnl)             !Db IN THIS CONTEXT ACTS AS A DUMMY
203                             !VARIABLE. DVM READS THE LOWER PROBE YAW TRANSDUCER.
204   CALL Readdvm(Db,Scnyawchnu)             !UPPER PROBE YAW TRANSDUCER IS READ.
205   PRINT "*****************************************************"
206   PRINT "LOWER PROBE YAW CHAN READING        ";Yawchnrdl
207   Yawl=Yawchnrdl*1000                    !THIS IS WHERE THE REFERENCING
208                                          !CORRECTION FOR THE YAW ANGLE IS MADE
210   PRINT "LOWER PROBE YAW (DEGREES)          ";Yawl
211   PRINT "UPPER PROBE YAW CHAN READING       ";Yawchnrdu
212   Yawu=Yawchnrdu*1000                    !MAKE THE REFERENCING CORRECTION FOR
213                                          !UPPER PROBE YAW ANGLE HERE.
215   PRINT "UPPER PROBE YAW (DEGREES)          ";Yawu
216   GOTO Continue
217 Readlprb:PRINT "SCAN NUMBER";Scan        !CODING FOR READING ONE PROBE BEGINS
218   PRINT "PROBE POSITION";Posit
219   PRINT "PORT         VOLTAGE      GUAGE PRESSURE(INCHES H2o)"
220   MAT Scanvb= (0)
221   FOR D=Dport TO Hport
222     CALL Scnvportposit(Scnvb,D,Scnhmsvcb,Scnstpsvcb)   !CALLS SUBROUTINE TO
223                                     !POSITION SCANIVALVE PORT.
225     CALL Readdvm(D,Scnrdsvc)        !CALLS SUBROUTINE TO READ SCANIVALVE PORTS
226                                     !ON THE DVM.
228    Prntdatb(1,1)=Scanvb(1,1)*10000             !SCALES DVM READINGS TO
229                                                !TO ENGINEERING UNITS.
231   IF D>1 THEN Prntdatb(1,D)=Scanvb(1,D)*10000-Prntdatb(1,1)     !PORT 1
232                                     !READING SUBTRACTED OFF THE SCANIVALVE
233                                     !PORT READINGS.
235     PRINT USING "DD,10X,MD.3DE,10X,MD.3DE";D,Scanvb(1,D),Prntdatb(1,D)
236   NEXT D
237   PRINT "*********************************************************"
238   CALL Readdvm(D,Scnyawchn)
239   PRINT "YAW CHAN READING                    ";Yawchnrd
240   Yaw=Yawchnrd*1000        !THIS IS WHERE TO CORRECT FOR PROBE YAW REFERENCING
241   PRINT "YAW (DEGREES)                       ";Yaw
242 Continue:CALL Readdvm(Db,Scntempchn)
243   PRINT "TEMP CHAN READING                   ";Tempchnrd
244   T=Tempchnrd*1000
245   Temp=33.91*T+34.25+460              !IRON CONSTANTAN THERMOCOUPLE EQUATION
246                                       !SAME ONE USED BY DREON.
248   PRINT "TEMPERATURE (DEGREES R)        ";Temp
249   Pa=Pbaro*13.57                      !ATMOSPHERIC PRESS CONVERTED TO INCHES H2o
250   PRINT USING "26A,4X,2D.2D,X,4A,5X,3D.2D,5A";"ATMOSPHERIC PRESS (INCHES)",P
baro,"(Hg)",Pa,"(H2o)"
251   PRINT ""
252   PRINT "************************************************************"
253   PRINT ""
254   PRINT "IS DATA OK? PRESS ""RECORD"" TO RECORD DATA, PRESS ""REPEAT"" TO"
255   PRINT "REPEAT THE SCAN."
256   PRINT ""
257   PRINT "************************************************************"
258   ON KEY 1 LABEL "RECORD" GOTO Storerawdata
259   ON KEY 4 LABEL "REPEAT" GOTO Repeatscan
260 Spin2:   GOTO Spin2
261 Repeatscan:    IF Noofprbs=2 THEN
262       GOTO Start2prbs
263     ELSE
264       GOTO Start1prb
265     END IF
266 Storerawdata:    ! STORE RAWDATA TO RAWDATA FILE
267   IF Noofprbs=2 THEN
268   MAT Rawdat= (0)
269   FOR K=1 TO 19
270   Rawdat(1,K)=Scanvb(1,K)        !ASSIGN ALL THE SCANIVALVE READINGS IN THE
```

```
271                                    !SCANVB ARRAY TO THE RAWDAT ARRAY ELEMENT
272                                    !BY ELEMENT
274     NEXT K
275     Rawdat(1,20)=Positl
276     Rawdat(1,21)=Positu
277     Rawdat(1,22)=Yawchnrdl
278     Rawdat(1,23)=Yawchnrdu
279     Rawdat(1,24)=Tempchnrd
280     Rawdat(1,25)=Pa
281     OUTPUT @Path1,Scan;Rawdat(*)            !THE DATA IS STORED IN THE RAW DATA
282                                             !FILE WHICH WAS PREVIOUSLY CREATED.
283                                             !THIS IS A RANDOM OUTPUT STATEMENT.
285     MAT Scaled= (0)
286     FOR K=1 TO 19
287     Scaled(1,K)=Prntdatb(1,K)               !SAME METHOD HERE EXCEPT SCALED DATA
288                                             !IS REASSIGNED.
290     NEXT K
291     Scaled(1,20)=Positl
292     Scaled(1,21)=Positu
293     Scaled(1,22)=Yawl
294     Scaled(1,23)=Yawu
295     Scaled(1,24)=Temp
296     Scaled(1,25)=Pa
297     OUTPUT @Path2,Scan;Scaled(*)
298     ELSE
299     MAT Rawdat= (0)
300     FOR K=1 TO 14                           !FOR THE ONE PROBE OPTION, ASSIGNS
301                                             !ALL THE SCANIVALVE READINGS IN THE
302                                             !ARRAY TO THE RAWDAT ARRAY ELEMENT
303                                             !BY ELEMENT.
305     Rawdat(1,K)=Scanvb(1,K)
306     NEXT K
307     Rawdat(1,15)=Posit
308     Rawdat(1,16)=Yawchnrd
309     Rawdat(1,17)=Tempchnrd
310     Rawdat(1,18)=Pa
311     OUTPUT @Path1,Scan;Rawdat(*)            !THE DATA IS STORED IN THE RAW DATA
312                                             !WHICH WAS PREVIOUSLY CREATED. THIS
313                                             !IS A RANDOM OUTPUT STATEMENT.
315     MAT Scaled= (0)
316     FOR K=1 TO 14
317     Scaled(1,K)=Prntdatb(1,K)               !SAME METHOD HERE EXCEPT SCALED DATA
318                                             !IS REASSIGNED.
320     NEXT K
321     Scaled(1,15)=Posit
322     Scaled(1,16)=Yaw
323     Scaled(1,17)=Temp
324     Scaled(1,18)=Pa
325     OUTPUT @Path2,Scan;Scaled(*)
326     END IF
327     PRINT "**********************************************************"
328     PRINT ""
329     PRINT "PRESS ""GO ON"" TO CONTINUE TAKING DATA, PRESS ""END PRB DATA"""
330     PRINT "TO TERMINATE PROBE DATA COLLECTION."
331     PRINT ""
332     PRINT "**********************************************************"
333     ON KEY 1 LABEL "END PRB DATA" GOTO Printfilename
334     ON KEY 4 LABEL "GO ON" GOTO Collectdata
335 Spin3:    GOTO Spin3
336 Collectdata:  IF Noofprbs=2 THEN
337             GOTO Start2prbs
338         ELSE
339         GOTO Start1prb
340       END IF
341       PRINT "**********************************************************"
342       PRINT ""
```

```
343 Printfilename:  PRINT "RAW PROBE DATA IS STORED "
344                 PRINT "IN DATA FILE",Rawfile$
345                 PRINT ""
346  PRINT "************************************************************"
347  PRINT ""
348  PRINT "PROBE RAW DATA SCALED TO ENGINEERING UNITS"
349  PRINT "IS STORED IN REDDATA FILE",Sclfile$
350  PRINT ""
351  PRINT "************************************************************"
352  PRINT ""
353  PRINT "ENSURE THE PROBE IS CLEAR OF THE INSTRUMENTED BLADE."
354  PRINT ""
355  PRINT "************************************************************"
356  PRINT ""
357  PRINT " PRESS ""COLLECT DATA"" TO COLLECT DATA FOR THE INSTRUMENTED BLADE"
358  PRINT " PRESS ""GO ON"" TO CONTINUE WITH THE PROGRAM."
359  PRINT ""
360  ON KEY 4 LABEL "GO ON" GOTO Printoption1
361  ON KEY 1 LABEL "COLLECT DATA" GOTO Namefile
362 Spin4:  GOTO Spin4
363 Namefile:  MASS STORAGE IS "/CLASSICK/DATA"      !CODING FOR INSTRUMENTED
364                                   !BLADE SECTION OF PROGRAM IS SAME AS FOR
                                      !PROBE SECTION.
366  PRINT "************************************************************"
367  PRINT ""
368  PRINT "NAME FILE FOR THE RAW DATA TO BE COLLECTED FROM THE BLADE."
369  INPUT Rawbladfile$
370  CREATE BDAT Rawbladfile$,100,384  !100 RECORDS, EACH RECORD CAN CONTAIN
371                                    !48 REAL NUMBERS 8X48=384.
373  ASSIGN @Path3 TO Rawbladfile$
374  MASS STORAGE IS "/CLASSICK/REDDATA"
375  PRINT "************************************************************"
376  PRINT ""
377  PRINT "NAME FILE FOR THE RAW BLADE DATA SCALED TO ENGINEERING UNITS."
378  INPUT Sclbladfile$
379  PRINT ""
380  PRINT "************************************************************"
381  CREATE BDAT Sclbladfile$,100,384
382  ASSIGN @Path4 TO Sclbladfile$
383 Bladeread:   MAT Scanva= (0)
384   PRINT "SCAN NUMBER",Scan
385   PRINT "PORT          VOLTAGE              GUAGE PRESS(INCHES H2o)"
386   FOR Da=Dporta TO Hporta
387   CALL Scnvportposit(Scnva,Da,Scnhmsvca,Scnstpsvca)
388   CALL Readdvm(Da,Scnrdsvca)
389   Prntdata(1,Da)=Scanva(1,Da)*10000
390  IF Da>1 THEN Prntdata(1,Da)=Scanva(1,Da)*10000-Prntdata(1,1)
391   PRINT USING "DD,10X,MD.3DE,10X,MD.3DE";Da,Scanva(1,Da),Prntdata(1,Da)
392   NEXT Da
393   PRINT "**********************************************************"
394   PRINT ""
395   PRINT "IS DATA OK? PRESS ""REPEAT"" TO REPEAT THE SCAN, PRESS ""RECORD"""
396   PRINT "TO RECORD THE DATA."
397   PRINT ""
398   PRINT "**********************************************************"
399   ON KEY 1 LABEL "RECORD" GOTO Storedata
400   ON KEY 4 LABEL "REPEAT" GOTO Bladeread
401 Spin5:    GOTO Spin5
402 Storedata:  OUTPUT @Path3;Scanva(*)
403   OUTPUT @Path4;Prntdata(*)
404   PRINT "THIS DATA IS ASSOCIATED WITH THE LAST SCAN OF FILE  ",Sclfile$
405   PRINT ""
406 Printoption1:  PRINT "**************************************************"
407  PRINT ""
408  PRINT "ALIGN PAPER IN PRINTER. "
409  PRINT ""
```

```
410  PRINT "TO PRINT OUT A TABULATION OF THE RAW DATA COLLECTED FROM"
411  PRINT ""
412  PRINT "THE PROBE(S), PRESS ""RAW TABLE"". PRESS ""GO ON"""
413  PRINT ""
414  PRINT "TO CONTINUE WITH THE PROGRAM."
415  PRINT ""
416  PRINT "**************************************************************"
417  ON KEY 1 LABEL "RAW     TABLE" GOTO Printrawtable
418  ON KEY 4 LABEL "GO ON" GOTO Printoption2
419 Spin6:  GOTO Spin6
420 Printrawtable:  MASS STORAGE IS "/CLASSICK/DATA"
421  ASSIGN @Path1 TO Rawfile$     !STATEMENT PUTS FILE POINTER AT BEGINING
422                                !OF FILE.
424  PRINT ""
425  PRINT "PRESS ""ONE PROBE"" IF ONE PROBE WAS USED."
426  PRINT "PRESS ""TWO PROBES"" IF TWO PROBES WERE USED."
427  PRINT ""
428  PRINT "**************************************************************"
429  ON KEY 1 LABEL "ONE     PROBE" GOTO Numberofprbs1
430  ON KEY 4 LABEL "TWO     PROBES" GOTO Numberofprbs2
431 Spin7:  GOTO Spin7
432 Numberofprbs1:  Noofprbs=1
433 GOTO Howmanyprbs
434 Numberofprbs2: Noofprbs=2
435 Howmanyprbs:     IF Noofprbs=2 THEN
436  PRINTER IS Prnter        !SENDS PRINT STATEMENTS TO THE PRINTER.
437  PRINT "*********************************************"
438  PRINT "PROBE RAW DATA FILE   ",Rawfile$
439  PRINT "*********************************************"
440  PRINT "SCAN   L PRB     1            2            3            4
 5"
441  PRINT "       POSIT"
442      FOR N=1 TO 100
443      ENTER @Path1,N;Rawdat(*)       !STATEMENT ACCESSES THE RAW DATA FILE IN
444                                     !RANDOM MODE.
446      ON END @Path1 GOTO Twoprintraw1      !SINCE ALL RECORDS OF A FILE MAY
447                                     !NOT BE FILLED (RECALL 100 RECORDS WERE
448                                     !RESERVED FOR 100 DATA POINTS), THE ON
449                                     !END STATEMENT ALLOWS THE PROGRAM TO
450                                     !CONTINUE AT THE Twoprintraw1 LINE WHEN
451                                     !AN END OF FILE CONDITION OCCURS.
453      Posit1=Rawdat(1,20)
454      Port1=Rawdat(1,1)
455      Port2=Rawdat(1,2)
456      Port3=Rawdat(1,3)
457      Port4=Rawdat(1,4)
458      Port5=Rawdat(1,5)
459  PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE"
;N,Posit1,Port1,Port2,Port3,Port4,Port5
460  NEXT N
461 Twoprintraw1:  PRINT "*****************************************************
**********************"
462  PRINT "SCAN   6           7           8           9           10
  11"
463  FOR N=1 TO 100
464  ENTER @Path1,N;Rawdat(*)
465  ON END @Path1 GOTO Twoprintraw2
466       Port6=Rawdat(1,6)
467       Port7=Rawdat(1,7)
468       Port8=Rawdat(1,8)
469       Port9=Rawdat(1,9)
470       Port10=Rawdat(1,10)
471       Port11=Rawdat(1,11)
472  PRINT USING "4D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3DE
";N,Port6,Port7,Port8,Port9,Port10,Port11
473  NEXT N
```

```
474 Twoprintraw2:  PRINT "*****************************************************
************************"
475 PRINT "SCAN   U PRB     12              13       -    14             15
16"
476    PRINT "         POSIT"
477    FOR N=1 TO 100
478    ENTER @Path1,N;Rawdat(*)
479    ON END @Path1 GOTO Twoprintraw3
480    Positu=Rawdat(1,21)
481    Port12=Rawdat(1,12)
482    Port13=Rawdat(1,13)
483    Port14=Rawdat(1,14)
484    Port15=Rawdat(1,15)
485    Port16=Rawdat(1,16)
486  PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE"
;N,Positu,Port12,Port13,Port14,Port15,Port16
487  NEXT N
488 Twoprintraw3:  PRINT "*****************************************************
************************"
489  PRINT "SCAN   17             18             19 "
490  FOR N=1 TO 100
491  ENTER @Path1,N;Rawdat(*)
492  ON END @Path1 GOTO Twoprintraw4
493  Port17=Rawdat(1,17)
494  Port18=Rawdat(1,18)
495  Port19=Rawdat(1,19)
496  Pa=Rawdat(1,25)
497  PRINT USING "4D,3X,MD.3DE,4X,MD.3DE,4X,MD.3DE";N,Port17,Port18,Port19
498  NEXT N
499 Twoprintraw4:  PRINT "*****************************************************
************************"
500   PRINT "SCAN   YAW L          YAW U          TEMPCHN        ATMOS"
501   PRINT "       VOLT           VOLT           VOLT           PRESSURE"
502  FOR N=1 TO 100
503  ENTER @Path1,N;Rawdat(*)
504  ON END @Path1 GOTO Twoprintraw5
505  Yawchnrdl=Rawdat(1,22)
506  Yawchnrdu=Rawdat(1,23)
507  Tempchnrd=Rawdat(1,24)
508  Pa=Rawdat(1,25)
509  PRINT USING "4D,3X,MD.3DE,4X,MD.3DE,4X,MD.3DE,4X,3D.2D";N,Yawchnrdl,Yawchnr
du,Tempchnrd,Pa
510   NEXT N
511 Twoprintraw5:  OFF END @Path1          !TERMINATES THE ON END COMMAND
512                ELSE
513   PRINTER IS Prnter
514   PRINT "******************************************"
515   PRINT "PROBE RAW DATA FILE   ",Rawfile$
516   PRINT "******************************************"
517   PRINT "SCAN  PROBE    1            2            3           4            5"
518   PRINT "       POSIT"
519   FOR N=1 TO 100
520   ENTER @Path1,N;Rawdat(*)          !STATEMENT ACCESSES THE RAW DATA FILE IN
521                                     !RANDOM MODE
523   ON END @Path1 GOTO Printraw1      !SINCE ALL RECORDS OF A FILE MAY NOT BE
524                                     !FILLED (RECALL 100 WERE USED FOR 100
525                                     !DATA POINTS), ON END STATEMENT ALLOWS THE
526                                     !PROGRAM TO CONTINUE AT THE Printraw1 LINE
528   Posit=Rawdat(1,15)
529   Port1=Rawdat(1,1)
530   Port2=Rawdat(1,2)
531   Port3=Rawdat(1,3)
532   Port4=Rawdat(1,4)
533   Port5=Rawdat(1,5)
534   PRINT USING "4D,2X,4D.2D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE
";N,Posit,Port1,Port2,Port3,Port4,Port5
```

```
535   NEXT N
536 Printraw1:   PRINT "*********************************************************
**********************"
537  PRINT "SCAN  6            7            8            9            10           11
"
538  FOR N=1 TO 100
539  ENTER @Path1,N;Rawdat(*)
540  ON END @Path1 GOTO Printraw2
541  Port6=Rawdat(1,6)
542  Port7=Rawdat(1,7)
543  Port8=Rawdat(1,8)
544  Port9=Rawdat(1,9)
545  Port10=Rawdat(1,10)
546  Port11=Rawdat(1,11)
547  PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE
";N,Port6,Port7,Port8,Port9,Port10,Port11
548  NEXT N
549 Printraw2:   PRINT "*********************************************************
***********************"
550  PRINT "SCAN  12           13           14           YAWCHAN      TEMPCHAN     AT
MOS"
551  PRINT "                                            VOLTAGE      VOLTAGE      PR
ESSURE"
552  FOR N=1 TO 100
553  ENTER @Path1,N;Rawdat(*)
554  ON END @Path1 GOTO Printraw3
555  Port12=Rawdat(1,12)
556  Port13=Rawdat(1,13)
557  Port14=Rawdat(1,14)
558  Yawchnrd=Rawdat(1,16)
559  Tempchnrd=Rawdat(1,17)
560  Pa=Rawdat(1,18)
561  PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,3D.2D"
;N,Port12,Port13,Port14,Yawchnrd,Tempchnrd,Pa
562  NEXT N
563 Printraw3:  PRINT "**********************************************************
*********************"
564   OFF END @Path1          !TERMINATES ON END STATEMENT
565   END IF
566   PRINTER IS Scren        !RETURNS PRINT STATEMENTS TO MONITOR.
567   PRINT "**************************************************************"
568   PRINT ""
569 Printoption2: PRINT "ALIGN PAPER IN PRINTER."
570               PRINT ""
571               PRINT "TO PRINTOUT A TABULATION OF THE PROBE DATA SCALED IN"
572               PRINT ""
573               PRINT "ENGINEERING UNITS, PRESS ""SCALED DATA""."
574               PRINT ""
575               PRINT "PRESS ""GO ON""TO CONTINUE WITH THE PROGRAM."
576  PRINT ""
577  PRINT "**************************************************************"
578  ON KEY 1 LABEL " SCALED  DATA" GOTO Prntscaledtable
579  ON KEY 4 LABEL "GO ON" GOTO Printoption3
580 Spin8:  GOTO Spin8
581 Prntscaledtable:      MASS STORAGE IS "/CLASSICK/REDDATA"
582       ASSIGN @Path2 TO Sclfile$
583       PRINT ""
584 PRINT "PRESS ""ONE PROBE"" IF ONE PROBE WAS USED."
585 PRINT "PRESS ""TWO PROBES "" IF TWO PROBES WERE USED."
586 PRINT ""
587 PRINT "***************************************************************"
588 ON KEY 1 LABEL "ONE     PROBE" GOTO Numberprobes1
589 ON KEY 4 LABEL "TWO     PROBES" GOTO Numberprobes2
590 Spin9: GOTO Spin9
591 Numberprobes1:  Noofprbs=1
592 GOTO Howmanyprobes
```

```
593 Numberprobes2: Noofprbs=2
594 Howmanyprobes:      IF Noofprbs=2 THEN
595  PRINTER IS Prnter
596  PRINT "**************************************************"
597  PRINT "PROBE SCALED DATA FILE   ",Sclfile$
598  PRINT "**************************************************"
599  PRINT "SCAN    L PRB       1             2             3             4
 5"
600  PRINT "        POSIT"
601      FOR N=1 TO 100
602      ENTER @Path2,N;Scaled(*)
603      ON END @Path2 GOTO Twoprintscl1
604      Positl=Scaled(1,20)
605      Port1=Scaled(1,1)
606      Port2=Scaled(1,2)
607      Port3=Scaled(1,3)
608      Port4=Scaled(1,4)
609      Port5=Scaled(1,5)
610  PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE"
;N,Positl,Port1,Port2,Port3,Port4,Port5
611  NEXT N
612 Twoprintscl1:  PRINT "****************************************************
************************"
613  PRINT "SCAN   6             7             8             9             10
 11"
614  FOR N=1 TO 100
615  ENTER @Path2,N;Scaled(*)
616  ON END @Path2 GOTO Twoprintscl2
617       Port6=Scaled(1,6)
618       Port7=Scaled(1,7)
619       Port8=Scaled(1,8)
620       Port9=Scaled(1,9)
621       Port10=Scaled(1,10)
622       Port11=Scaled(1,11)
623  PRINT USING "4D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3DE
";N,Port6,Port7,Port8,Port9,Port10,Port11
624  NEXT N
625 Twoprintscl2:  PRINT "************************* *************************
*************************"
626  PRINT "SCAN    U PRB      12            13            14            15
 16"
627  PRINT "        POSIT"
628    FOR N=1 TO 100
629    ENTER @Path2,N;Scaled(*)
630    ON END @Path2 GOTO Twoprintscl3
631    Positu=Scaled(1,21)
632    Port12=Scaled(1,12)
633    Port13=Scaled(1,13)
634    Port14=Scaled(1,14)
635    Port15=Scaled(1,15)
636    Port16=Scaled(1,16)
637  PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE"
;N,Positu,Port12,Port13,Port14,Port15,Port16
638  NEXT N
639 Twoprintscl3:  PRINT "****************************************************
************************"
640   PRINT "SCAN   17            18            19 "
641  FOR N=1 TO 100
642  ENTER @Path2,N;Scaled(*)
643  ON END @Path2 GOTO Twoprintscl4
644  Port17=Scaled(1,17)
645  Port18=Scaled(1,18)
646  Port19=Scaled(1,19)
647  PRINT USING "4D,3X,MD.3DE,4X,MD.3DE,4X,MD.3DE";N,Port17,Port18,Port19
648  NEXT N
649 Twoprintscl4:  PRINT "****************************************************
```

```
650  PRINT "SCAN   YAW L          YAW U          TEMP           ATMOS"
651  PRINT "        DEG            DEG            (R)            PRESSURE"
652  FOR N=1 TO 100
653  ENTER @Path2,N;Scaled(*)
654  ON END @Path2 GOTO Twoprintscl5
655  Yawl=Scaled(1,22)
656  Yawu=Scaled(1,23)
657  Temp=Scaled(1,24)
658  Pa=Scaled(1,25)
659  PRINT USING "4D,3X,MD.3DE,4X,MD.3DE,4X,MD.3DE,4X,3D.2D";N,Yawl,Yawu,Temp,Pa
660  NEXT N
661 Twoprintscl5:  OFF END @Path2
662                ELSE
663              !  END IF
664  PRINTER IS Prnter
665  PRINT "**********************************************"
666  PRINT "PROBE SCALED DATA FILE    ",Sclfile$
667  PRINT "**********************************************"
668  PRINT "SCAN   PROBE     1              2              3              4
  5"
669  PRINT "        POSIT"
670  FOR N=1 TO 100
671  ENTER @Path2,N;Scaled(*)
672  ON END @Path2 GOTO Printscl1
673  Posit=Scaled(1,15)
674  Port1=Scaled(1,1)
675  Port2=Scaled(1,2)
676  Port3=Scaled(1,3)
677  Port4=Scaled(1,4)
678  Port5=Scaled(1,5)
679  PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE
";N,Posit,Port1,Port2,Port3,Port4,Port5
680  NEXT N
681 Printscl1:   PRINT "****************************************************
**********************"
682  PRINT "SCAN  6             7              8              9              10             11
"
683  FOR N=1 TO 100
684  ENTER @Path2,N;Scaled(*)
685  ON END @Path2 GOTO Printscl2
686  Port6=Scaled(1,6)
687  Port7=Scaled(1,7)
688  Port8=Scaled(1,8)
689  Port9=Scaled(1,9)
690  Port10=Scaled(1,10)
691  Port11=Scaled(1,11)
692  PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE
";N,Port6,Port7,Port8,Port9,Port10,Port11
693  NEXT N
694 Printscl2:   PRINT "****************************************************
******************"
695  PRINT "SCAN  12            13             14             YAW            TEMP           AT
MOS"
696  PRINT "                                                 DEG            (R)            PR
ESS"
697  FOR N=1 TO 100
698  ENTER @Path2,N;Scaled(*)
699  ON END @Path2 GOTO Printscl3
700  Port12=Scaled(1,12)
701  Port13=Scaled(1,13)
702  Port14=Scaled(1,14)
703  Yaw=Scaled(1,16)
704  Temp=Scaled(1,17)
705  Pa=Scaled(1,18)
706  PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,3D.2D"
```

```
;N,Port12,Port13,Port14,Yaw,Temp,Pa
707  NEXT N
708 Printscl3:  PRINT "*************************************************************
******************"
709   OFF END @Path2
710   END IF
711  PRINTER IS Scren
712  PRINT "************************************************************"
713   PRINT ""
714 Printoption3: PRINT "PRESS ""BLADE DATA"" FOR BLADE DATA PRINT OPTIONS."
715               PRINT ""
716               PRINT "PRESS ""GO ON"" TO CONTINUE PROGRAM."
717               PRINT ""
718  PRINT "*************************************************************
"
719  ON KEY 1 LABEL "BLADE   DATA" GOTO Printoption4
720  ON KEY 4 LABEL "GO ON" GOTO Loadoption1
721 Spin10:  GOTO Spin10
722 Printoption4: PRINT ""
723               PRINT "ALIGN PAPER IN PRINTER."
724               PRINT ""
725               PRINT "TO PRINT OUT A TABULATION OF THE RAW BLADE DATA"
726               PRINT ""
727               PRINT "PRESS ""BLADE DATA"". PRESS ""GO ON"" TO CONTINUE."
728               PRINT ""
729      PRINT "*********************************************************
"
730      ON KEY 1 LABEL "BLADE   DATA" GOTO Prntbladedata
731      ON KEY 4 LABEL "GO ON" GOTO Printoption5
732 Spin11:      GOTO Spin11
733 Prntbladedata:     MASS STORAGE IS "/CLASSICK/DATA"
734      ASSIGN @Path3 TO Rawbladfile$
735      PRINTER IS Prnter
736      PRINT "*****************************************************"
737      PRINT "BLADE RAW DATA FILE    ",Rawbladfile$
738      PRINT "*****************************************************"
739      PRINT ""
740      PRINT "PROBE DATA ASSOCIATED WITH THE BLADE DATA IS CONTAINED"
741      PRINT "IN FILE:  ",Rawfile$
742      PRINT "SCAN:",Scan
743      PRINT "SCANIVALVE             VOLTAGE"
744      PRINT "PORT                   READING"
745      FOR N=1 TO 48
746      ENTER @Path3;Scanva(1,N)
747      PRINT USING "DD,20X,MD.3DE";N,Scanva(1,N)
748      NEXT N
749      PRINTER IS Scren
750 Printoption5:  PRINT "**********************************************"
751      PRINT ""
752      PRINT "ALIGN PAPER IN PRINTER."
753      PRINT ""
754      PRINT "TO PRINT OUT A TABULATION OF THE BLADE DATA SCALED TO "
755      PRINT ""
756      PRINT "ENGINEERING UNITS, PRESS ""SCALED DATA""."
757      PRINT ""
758      PRINT "PRESS ""GO ON"" TO TERMINATE PROGRAM."
759      PRINT ""
760      ON KEY 1 LABEL "SCALED  DATA" GOTO Prntscldbladdat
761      ON KEY 4 LABEL "GO ON" GOTO Loadoption1
762 Spin12:      GOTO Spin12
763 Prntscldbladdat:     MASS STORAGE IS "/CLASSICK/REDDATA"
764      ASSIGN @Path4 TO Sclbladfile$
765      PRINTER IS Prnter
766      PRINT "*****************************************************"
767      PRINT "BLADE SCALED DATA FILE    ",Sclbladfile$
768      PRINT "*****************************************************"
```

```
769      PRINT ""
770      PRINT "PROBE DATA ASSOCIATED WITH THE BLADE DATA IS CONTAINED"
771      PRINT "IN FILE:  ",Sclfile$
772      PRINT "SCAN:",Scan
773      PRINT "SCANIVALVE            PRESS (INCHES H2o)"
774      PRINT "PORT"
775      FOR N=1 TO 48
776      ENTER @Path4;Prntdata(1,N)
777      PRINT USING "DD,20X,MD.3DE";N,Prntdata(1,N)
778      NEXT N
779 Loadoption1:  PRINTER IS Scren
780      PRINT "*******************************************************"
781      PRINT ""
782      PRINT "TO LOAD PROGRAM TO REDUCE THE ACQUIRED DATA"
783      PRINT ""
784      PRINT "PRESS ""CALC"".  PRESS ""GO ON"" TO TERMINATE THE PROGRAM"
785      PRINT ""
786      PRINT "*******************************************************"
787      ON KEY 1 LABEL "CALC" GOTO Loadup1
788      ON KEY 4 LABEL "GO ON" GOTO Fin
789 Spin13:      GOTO Spin13
790 Loadup1: MASS STORAGE IS "/CLASSICK/PROGS"
791         LOAD "CALC",10
792 Fin: PRINT "*******************************************************"
793      PRINT "*******************************************************"
794      PRINT ""
795      PRINT "                  END OF PROGRAM"
796      PRINT ""
797      PRINT "*******************************************************"
798      PRINT "*******************************************************"
799      END
```

B7.2 Reduction Program CALC

```
10    !PROGRAM CALC
20    ! THIS PROGRAM TAKES THE FILES OF DATA COLLECTED FROM THE PROBE(S)
30    ! AND REDUCES THE DATA TO  USEFUL ENGINEERING QUANTITIES THESE
40    ! VALUES ARE PRINTED IN TABLE FORM.
41    !MUCH OF THE CODING IN THIS PROGRAM HAS BEEN PREVIOUSLY COMMENTED ON
42    !IN PROGRAM ACQUIRE.
50    OPTION BASE 1
70    DIM Reddat(1,106)                 !AN ARRAY FOR THE SCALED DATA FROM ACQUIRE.
71                                      !RECALL THAT THE SCALED DATA WAS STORED BY
72                                      !A RANDOM OUTPUT STATEMENT.
80    DIM P(6,6)                        !THE ARRAY FOR THE PHI COEFFICIENTS.
90    DIM X(6,6)                        !THE ARRAY FOR THE X VELOCITY COEFFICIENTS.
91    DIM Pu(6,6)                       !IF 2 PROBES USED THEN THE PHI ARRAY FOR
92                                      !THE UPPER PROBE.
94    DIM Xu(6,6)
95    DIM Knaray(100)                   !KN VALUES STORED IN AN ARRAY.Kn=K IN TABLE
96                                      !I OF CLASSICK THESIS.
98    DIM Prbpos(100)
99    DIM Aaray(100)                    !AN ARRAY OF VALUES USED IN THE CALCULATION
101   DIM Baray(100)                    !OF BLADE CP'S.
102   MAT Reddat= (0)
103   MAT Knaray= (0)
104   MAT Prbpos= (0)
105   MAT Aaray= (0)
106   MAT Baray= (0)
107   DEG                               !ALL ANGLES WILL BE IN DEGREES.
108   Prnter=701
109   Scren=1
110   Firstbladeprt=4                   !FIRST SCANIVALVE PORT ASSIGNED TO THE
111                                     !INSTRUMENTED BLADE THAT IS OF INTEREST
112                                     !IN THE CP CALCULATION.
114   Lastbladeprt=48                   !LAST " " "ect.
115   G=1.4
116   Cp=.24
120   LOADSUB ALL FROM "/CLASSICK/ROUTINES/SUBCALC"
130   MASS STORAGE IS "/CLASSICK/REDDATA"
131   PRINT "****************************************************************"
132   PRINT ""
134   PRINT "ENTER THE NAME OF THE FILE CONTAINING THE PROBE DATA SCALED"
135   PRINT "TO ENGINEERING UNITS"
136   INPUT Sclfile$
140   ASSIGN @Path1 TO Sclfile$
141   PRINT "****************************************************************"
142   PRINT ""
144   PRINT "ENTER THE PROBE COEFFICIENT FILE FOR X VELOCITY. THIS WILL BE "
145   PRINT ""
146   PRINT "FOR THE LOWER PROBE IF TWO PROBES ARE BEING USED."
148   INPUT Readx$
151   ASSIGN @Path2 TO Readx$
160   ENTER @Path2;X(*)
161   PRINT "****************************************************************"
162   PRINT ""
170   PRINT "ENTER THE NAME OF THE COEFFICIENT FILE FOR PHI. THIS WILL BE "
171   PRINT ""
172   PRINT "FOR THE LOWER PROBE IF TWO PROBES ARE BEING USED."
174   INPUT Readp$
180   ASSIGN @Path3 TO Readp$
190   ENTER @Path3;P(*)
191   PRINT "****************************************************************"
192   PRINT ""
200   PRINT "IF DATA WERE COLLECTED WITH ONE PROBE, PRESS "" ONE PROBE"""
201   PRINT ""
220   PRINT "IF DATA WERE COLLECTED WITH TWO PROBES, PRESS ""TWO PROBES"""
221   PRINT ""
```

```
224   PRINT "****************************************************************"
225   ON KEY 1 LABEL "ONE     PROBE" GOTO Numberprbs1
226   ON KEY 4 LABEL "TWO     PROBES" GOTO Numberprbs2
227 Spin1:    GOTO Spin1
228 Numberprbs1:    Noofprbs=1
229   GOTO Checknoofprbs
231 Numberprbs2:    Noofprbs=2
240 Checknoofprbs:  IF Noofprbs=2 THEN
250   MASS STORAGE IS "/CLASSICK/REDDATA"
251   PRINT "*****************************************************************"
252   PRINT ""
253   PRINT "ENTER THE FILE NAME FOR THE UPPER PROBE COEFFICIENTS FOR Xvel."
254   INPUT Readxu$
255   ASSIGN @Path2u TO Readxu$
256   ENTER @Path2u;Xu(*)
259   PRINT "*****************************************************************"
260   PRINT ""
261   PRINT "ENTER THE FILE NAME FOR THE UPPER PROBE COEFFICIENTS FOR PHI."
262   INPUT Readpu$
263   ASSIGN @Path3u TO Readpu$
264   ENTER @Path3u;Pu(*)
267   PRINT "****************************************************************"
268   PRINT ""
269   PRINT "ENTER THE FILENAME FOR THE DATA TO BE CALCULATED FROM LOWER PROBE "
270   INPUT Calclfile$
273   CREATE BDAT Calclfile$,100
274   ASSIGN @Path4 TO Calclfile$
275   PRINT "****************************************************************"
276   PRINT ""
277   PRINT "ENTER THE FILENAME FOR THE DATA TO BE CALCULATED  FROM UPPER PROBE"
278   INPUT Calcufile$
281   CREATE BDAT Calcufile$,100
282   ASSIGN @Path5 TO Calcufile$
283   !****************************************************************
284   !*       NOTE: THE SCANIVALVE SENSES THE PRESSURE DIFFERENTIAL FROM    *
285   !*              ATMOS. THE SCANIVALVE IS CALIBRATED SO ATMOS PRESS(Pa)  *
286   !*              READS ZERO. THE PRESS SENSED AT A PORT IS THE PORT      *
287   !*              PRESS MINUS Pa i.e.,GAGE PRESS. TO ELIMINATE ERRORS DUE *
288   !*              TO DVM DRIFT, THE  PRESS SENSED BY PORT 1 OF THE        *
289   !*              SCANIVALVE (Ptare=Pa-Pa) IS SUBTRACTED FROM EACH        *
290   !*              SCANIVALVE PORT READING.                                *
291   !*                                                                      *
292   !********************* TWO PROBES **********************************
293   !**********SCANIVALVE PORT AND SCANNER CHANNEL ASSIGNMENT**************
294   !*                                                                      *
295   !*                                                                      *
296   !*  VARIABLE    VARIABLE            PORT/CHANNEL    DATA ARRAY          *
297   !*              REPRESENTS                                              *
298   !*                                                                      *
299   !*  Ptare       Pa-Pa               PORT  1         Reddat(1,1)         *
300   !*  Pcal        Pcal-Ptare          PORT  2         Reddat(1,2)         *
301   !*  Pp          Pplenum-Ptare       PORT  3         Reddat(1,3)         *
302   !*  Ps          Pwallstatic-Ptare   PORT  4         Reddat(1,4)         *
303   !*  P1          P1-Ptare            PORT  5         Reddat(1,5)         *
304   !*  P2          P2-Ptare            PORT  6         Reddat(1,6)         *
305   !*  P3          P3-Ptare            PORT  7         Reddat(1,7)         *
306   !*  P23         (P2+P3)/2                                               *
307   !*  P4          P4-Ptare            PORT  8         Reddat(1,8)         *
308   !*  P5          P5-Ptare            PORT  9         Reddat(1,9)         *
309   !*  Ptp        Ptotalprndtl-Ptare   PORT  10        Reddat(1,10)        *
310   !*  Psp        Pstatprndtl-Ptare    PORT  11        Reddat(1,11)        *
311   !*              BLANK               PORT  12        Reddat(1,12)        *
312   !*  P1u         P1u-Ptare           PORT  13        Reddat(1,13)        *
313   !*  P2u         P2u-Ptare           PORT  14        Reddat(1,14)        *
314   !*  P3u         P3u-Ptare           PORT  15        Reddat(1,15)        *
315   !*  P23u        (P2u+P3u)/2                                             *
```

```
316  !*  P4u       P4u-Ptare             PORT 16        Reddat(1,16)        *
317  !*  P5u       P5u-Ptare             PORT 17   -    Reddat(1,17)        *
318  !*             BLANK                PORT 18        Reddat(1,18)        *
319  !*             BLANK                PORT 19        Reddat(1,19)        *
320  !*  Posit     L PRB POSIT           INPUT          Reddat(1,20)        *
321  !*  Positu    U PRB POSIT           INPUT          Reddat(1,21)        *
322  !*  Yaw       LOWER PRB YAW         24             Reddat(1,22)        *
323  !*  Yawu      UPPER PRB YAW         21             Reddat(1,23)        *
324  !*  Temp      TOTAL TEMP(PLENUM)    CHAN 10        Reddat(1,24)        *
325  !*  Pa        ATMOSPHERIC PRESS     INPUT          Reddat(1,25)        *
326  !*                                                                     *
327  !*                                                                     *
328  !**********************************************************************
329  !*******************DATA REDUCTION*************************************
330  DIM Calcl(100,25)
331  MAT Calcl= (0)
332  Pinitiall=0                     !INITIALIZES THE CONDITIONS TO CALCULATE
333                                  !ENSEMBLE VALUES IN SUBROUTINE ENSEMBLE
335  Tinitial=0
336  Painitiall=0
337  FOR N=1 TO 100
338  ENTER @Path1,N;Reddat(*)        !THE ARRAY IS ENTERED WITH A RANDOM
339                                  !STATEMENT.
341  ON END @Path1 GOTO Twoprintcalcl
342  Ptare=Reddat(1,1)               !REASSIGNMENT OF ARRAY ELEMENTS TO
343                                  !IDENTIFIABLE QUANTITIES TO BE USED IN
344                                  !IN SUBROUTINE CALCULATIONS.
346  Pcal=Reddat(1,2)
347  Pp=Reddat(1,3)
348  Ps=Reddat(1,4)
349  P1=Reddat(1,5)
350  P2=Reddat(1,6)
351  P3=Reddat(1,7)
352  P23=(P2+P3)/2
353  P4=Reddat(1,8)
354  P5=Reddat(1,9)
355  Ptp=Reddat(1,10)
356  Psp=Reddat(1,11)
357  !BLANK=Reddat(1,12)
358  Posit=Reddat(1,20)
359  Yaw=Reddat(1,22)                    !YAW ANGLE CORRECTION COULD BE MADE
360                                      !HERE IF NOT ALREADY DONE IN ACQUIRE.
362  Temp=Reddat(1,24)
363  Pa=Reddat(1,25)
364  !CALCULATE BETA AND GAMMA COEFFICIENTS
365  CALL Bgcalc(Pa,P1,P23,P4,P5,Beta,Gamma)
366  !CALCULATE THE ENSEMBLE REFERENCE VALUES OF PLENUM PRESS,PLENUM TEMP AND PA
367  CALL Ensemble(Pp,Pinitial,Pa,Painitial,Temp,Tinitial,Ppavg,Paavg,Tempavg,N)
368  !CALCULATE Xvel AND Phi
369  CALL Xphicalc(Beta,Gamma,Xvel,X(*),Phi,P(*))
370  !CALCULATE Xref
371  CALL Xrefcalc(Pa,Pp,6,Xref)
372  !CALCULATE QREF AND VREF
373  CALL Qvrefcalc(Xref,Cp,Temp,6,Pp,Pa,Qref,Vref)
374  !CALCULATE VELOCITY AND MACH # AND Q
375  CALL Vmqcalc(Xvel,Cp,Temp,6,Vel,Mach,P1,Pa,Q)
376  ! CALCULATE THE INTEGRAND FOR THE AVDR EXPRESSION
377  CALL Kncalc(Pa,P1,Pp,Xvel,Xref,6,Yaw,Kn)
378  !CALCULATE THE COEFFICIENT OF PRESSURE TERM TO BE MASS AVERAGED.
379  !THESE TERMS ARE USED IN THE CALCULATION OF THE LOSS COEFFICIENT.
380  CALL Coefpress(P1,Pp,Pa,Xvel,6,Cps,Cpt)
381  !CALCULATE THE  QUANTITIES TO BE MASS AVERAGED. MULTIPLY THESE VALUES
382  !BY Kn TO GET THE INTEGRAND REQUIRED TO CALCULATE THE MASS AVERAGED CP'S
383  CALL Cpintegrand(Pp,P1,Pa,6,Xvel,A,B,Kn)
384  ! CALCULATE Pp-P1/Qref FOR PLOTS
385  CALL Prefqref(Pp,P1,Qref,Pq)
```

```
386   ! CALCULATE STATIC PRESSURE UPSTREAM
387   CALL Staticpress(P1,Pa,Xvel,G,Ps)
389   !DEFINE AN ARRAY TO STORE CALCULATED VALUES
390   Calcl(N,1)=Posit
391   Calcl(N,2)=Beta
392   Calcl(N,3)=Gamma
393   Calcl(N,4)=Phi
394   Calcl(N,5)=Xvel
395   Calcl(N,6)=Xref
396   Calcl(N,7)=Vel
397   Calcl(N,8)=Mach
398   Calcl(N,9)=Yaw
399   Calcl(N,10)=Kn
400   Calcl(N,11)=Cpt
401   Calcl(N,12)=Cps
402   Calcl(N,13)=Qref
403   Calcl(N,14)=Vref
404   Calcl(N,15)=Q
405   Calcl(N,16)=A
406   Calcl(N,17)=B
407   Calcl(N,18)=Pq
408   Calcl(N,19)=Pa                       !Pa & Ps ARE USED FOR STATIC PRESS
409                                        !RISE CALCULATION IN PROGRAM LOSS.
411   Calcl(N,20)=Ps                       !THESE VALUES ARE NOT PRINTED.
412   Knaray(N)=Calcl(N,10)                !WANT TO STORE MORE THAN JUST ONE
413                                        !Kn VALUE FOR MASS AVERAGING
414                                        !CALCULATIONS.
415   Prbpos(N)=Calcl(N,1)                 !"" ""
416   Aaray(N)=Calcl(N,16)                 !"" ""
417   Baray(N)=Calcl(N,17)                 !"" ""
418   Scan=N
419   NEXT N
420 Twoprintcalcl:   OFF END @Path1
421   !CALCULATE ENSEMBLE AVERAGE OF XREF
422   CALL Xrefensemble(Paavg,Ppavg,G,Xrefavg)
423   !CALCULATE ENSEMBLE AVERAGE OF VREF
424   CALL Vrefensemble(Xrefavg,Cp,Tempavg,Vrefavg)
425   !CALCULATE ENSEMBLE AVERAGE OF QREF
426   CALL Qrefensemble(Paavg,Ppavg,G,Xrefavg,Qrefavg)
427   PRINT "************************************************************"
428   PRINT ""
429   PRINT "ALIGN PAPER IN PRINTER. WHEN READY FOR A HARDCOPY OF THE "
430   PRINT "CALCULATED DATA, PRESS ""REDUCED DATA""."
431   PRINT ""
432   PRINT "************************************************************"
433   ON KEY 1 LABEL "REDUCED DATA" GOTO Prntdata2
434 Spin2:   GOTO Spin2
435 Prntdata2:   PRINTER IS Prnter
436   PRINT "*******************************"
437   PRINT "FILE  ",Calclfile$
438   PRINT "*******************************"
439   PRINT "**************************************************************
*************"
440   PRINT ""
441   PRINT "SCAN   L PRB     BETA          GAMMA        PHI          Xvel
Xref "
442   PRINT "        POSIT"
443   FOR N=1 TO Scan
444   PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3DE
";N,Calcl(N,1),Calcl(N,2),Calcl(N,3),Calcl(N,4),Calcl(N,5),Calcl(N,6)
445   NEXT N
446   PRINT ""
447   PRINT "**************************************************************
*************"
448   PRINT ""
449   PRINT "SCAN   VEL          VREF          Q             QREF         MACH
```

```
  YAW"
450  PRINT "
  DEG  "
451  FOR N=1 TO Scan
452  PRINT USING "4D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3D
E";N,Calcl(N,7),Calcl(N,14),Calcl(N,15),Calcl(N,13),Calcl(N,8),Calcl(N,9)
453  NEXT N
454  PRINT ""
455  PRINT "**************************************************************
*************"
456  PRINT ""
457  PRINT "**************************************************************
**************"
458  PRINT ""
459  PRINT "SCAN   Pref-Pt1/Qref"
460  FOR N=1 TO Scan
461  PRINT USING "4D,3X,MD.3DE";N,Calc(N,18)
462  NEXT N
463  PRINT ""
464  PRINT "**************************************************************
***************"
465  PRINT ""
466  PRINT "ENSEMBLE AVERAGES"
467  PRINT ""
468  PRINT "PPAVG            PAAVG            TEMPAVG     XREFAVG          VREFAVG
  QREFAVG "
469  PRINT USING "MD.3DE,5X,M3D.2DE,5X,3D.2D,5X,MD.3DE,5X MD.3DE,3X,MD.3DE";Ppa
vg,Paavg,Tempavg,Xrefavg,Vrefavg,Qrefavg
470  OUTPUT @Path4;Calcl(*)                 !OUTPUT STATEMENT IS SERIAL.
471  DIM Calcu(100,25)                      !SEPARATE CALC ARRAY FOR REDUCED
472                                         !DATA FROM UPPER SURVEY STATION.
473  MAT Calcu= (0)
474  FOR N=1 TO 100
475  ENTER @Path1,N;Reddat(*)               !ENTER STATEMENT IS RANDOM.
476  ON END @Path1 GOTO Twoprintcalc2
477  Ptare=Reddat(1,1)
478  Pp=Reddat(1,3)
479  Ps=Reddat(1,4)
480  Ptp=Reddat(1,10)
481  Psp=Reddat(1,11)
482  P1u=Reddat(1,13)
483  P2u=Reddat(1,14)
484  P3u=Reddat(1,15)
485  P2u3u=(P2u+P3u)/2
486  P4u=Reddat(1,16)
487  P5u=Reddat(1,17)
488  !BLANK=REDDAT(1,18)
489  !BLANK=REDDAT(1,19)
490  Positu=Reddat(1,21)
491  Yawu=Reddat(1,23)
492  Temp=Reddat(1,24)
493  Pa=Reddat(1,25)
494  !CALCULATE BETA AND GAMMA COEFFICIENTS
495  CALL Bgcalc(Pa,P1u,P2u3u,P4u,P5u,Betau,Gammau)
496  !CALCULATE Xvelu AND Phiu
497  CALL Xphicalc(Betau,Gammau,Xvelu,Xu(*),Phiu,Pu(*))
498  !CALCULATE Xrefu
499  CALL Xrefcalc(Pa,Pp,G,Xrefu)
500  !CALCULATE QREF AND VREF
501  CALL Qvrefcalc(Xref,Cp,Temp,G,Pp,Pa,Qref,Vref)
502  !CALCULATE VELOCITYu AND MACHu * AND Qu
503  CALL Vmqcalc(Xvelu,Cp,Temp,G,Velu,Machu,P1u,Pa,Qu)
504  ! CALCULATE THE INTEGRAND FOR THE AVDR EXPRESSION
505  CALL Kncalc(Pa,P1u,Pp,Xvelu,Xrefu,G,Yawu,Knu)
506  ! CALCULATE THE COEFFICIENT OF PRESSURE FOR THE UPPER PROBE.
507  ! THIS TERM WILL BE MASS AVERAGED AND USED IN THE CALCULATION OF THE
```

```
508   ! LOSS COEFFICIENT. THE Cpsu TERM IS NOT USED IN THE LOSS COEFFICIENT
509   ! CALCULATION.
510   CALL Coefpress(Plu,Pp,Pa,Xvelu,G,Cpsu,Cptu)
511   ! CALCULATE Pp-Pl/Qref FOR PLOTS
512   CALL Prefqref(Pp,Pl,Qref,Pqu)
513   ! CALCULATE THE DOWNSTREAM STATIC PRESSURE
514   CALL Staticpress(Plu,Pa,Xvelu,G,Psu)
516   Calcu(N,1)=Posltu
517   Calcu(N,2)=Betau
518   Calcu(N,3)=Gammau
519   Calcu(N,4)=Phiu
520   Calcu(N,5)=Xvelu
521   Calcu(N,6)=Xrefu
522   Calcu(N,7)=Velu
523   Calcu(N,8)=Machu
524   Calcu(N,9)=Yawu
525   Calcu(N,10)=Knu
526   Calcu(N,11)=Cptu
527   Calcu(N,12)=Cpsu
528   Calcu(N,13)=Qu
529   Calcu(N,14)=Pqu
530   Calcu(N,19)=Pa                    !Calcu(N,15) TO Calcu(N,18) WILL HAVE
531   Calcu(N,20)=Psu                   !ZEROS. ARRAY ELEMENT ASSIGNMENT IS
532                                     !CONSISTENT WITH LOSS PROGRAM AND
533                                     !ONE PROBE SURVEY.
535   Scan=N
536   NEXT N
537 Twoprintcalc2:   OFF END @Path1
538   PRINT "*****************************************************************
*************"
539   PRINT ""
540   PRINT "**********************************"
541   PRINT "FILE    ",Calcufile$
542   PRINT "**********************************"
543   PRINT "*****************************************************************
*************"
544   PRINT ""
545   PRINT "SCAN  U PRB     BETAU        GAMMAU       PHIU         Xvelu "
546   PRINT "      POSIT"
547   FOR N=1 TO Scan
548   PRINT USING "4D,2X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE";N,Calcu(
N,1),Calcu(N,2),Calcu(N,3),Calcu(N,4),Calcu(N,5)
549   NEXT N
550   PRINT "*****************************************************************
*************"
551   PRINT ""
552   PRINT "SCAN   VELU         QU         Pref-Plu/Qref   MACHU        YAWU"
553   PRINT "                                                            DEG"
554   FOR N=1 TO Scan
555   PRINT USING "4D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE";N,Calcu
(N,7),Calcu(N,13),Calcu(N,14),Calcu(N,8),Calcu(N,9)
556   NEXT N
557   PRINT "*****************************************************************
*************"
558   PRINTER IS Scren
559   OUTPUT @Path5;Calcu(*)
560   ELSE
561   MASS STORAGE IS "/CLASSICK/REDDATA"
562   PRINT "*****************************************************************
*
563   PRINT ""
564   PRINT "ENTER THE FILENAME FOR THE DATA TO BE CALCULATED FROM THE PROBE "
565   INPUT Calcfile$
566   CREATE BDAT Calcfile$,100
567   ASSIGN @Path4 TO Calcfile$
568   !*****************************************************************
```

```
569   !********************** ONE PROBE ***********************************
570   !**********SCANIVALVE PORT AND SCANNER CHANNEL ASSIGNMENT**************
571   !*                                                                    *
572   !*                                                                    *
573   !*  VARIABLE     VARIABLE           PORT/CHANNEL    DATA ARRAY        *
574   !*               REPRESENTS                                           *
575   !*                                                                    *
576   !*  Ptare        Pa-Pa              PORT 1          Reddat(1,1)       *
577   !*  Pcal         Pcal-Ptare         PORT 2          Reddat(1,2)       *
578   !*  Pp           Pplenum-Ptare      PORT 3          Reddat(1,3)       *
579   !*  Ps           Pwallstatic-Ptare  PORT 4          Reddat(1,4)       *
580   !*  P1           P1-Ptare           PORT 5          Reddat(1,5)       *
581   !*  P2           P2-Ptare           PORT 6          Reddat(1,6)       *
582   !*  P3           P3-Ptare           PORT 7          Reddat(1,7)       *
583   !*  P23          (P2+P3)/2                                            *
584   !*  P4           P4-Ptare           PORT 8          Reddat(1,8)       *
585   !*  P5           P5-Ptare           PORT 9          Reddat(1,9)       *
586   !*  Ptp         Ptotalprndtl-Ptare  PORT 10         Reddat(1,10)      *
587   !*  Psp         Pstatprndtl-Ptare   PORT 11         Reddat(1,11)      *
588   !*                BLANK             PORT 12         Reddat(1,12)      *
589   !*                BLANK             PORT 13         Reddat(1,13)      *
590   !*                BLANK             PORT 14         Reddat(1,14)      *
591   !*  Posit       PRB POSIT           INPUT           Reddat(1,15)      *
592   !*  Yaw         PRB YAW             CHAN 24         Reddat(1,16)      *
593   !*  Temp        TOTAL TEMP(PLENUM)  CHAN 10         Reddat(1,17)      *
594   !*  Pa          ATMOSPHERIC PRESS   INPUT           Reddat(1,18)      *
595   !*                                                                    *
596   !*                                                                    *
597   !**********************************************************************
598   !*******************DATA REDUCTION*************************************
599   DIM Calc(100,25)
600   MAT Calc= (0)
601   Pinitial=0                         !INTIALIZES CONDITIONS FOR ENSEMBLE
602                                      !CALCULATIONS IN SUBROUTINE ENSEMBLE.
603   Tinitial=0
604   Painitial=0
605   FOR N=1 TO 100
606   ENTER @Path1,N;Reddat(*)           !ARRAY ENTERED RANDOMLY
607   ON END @Path1 GOTO Printcalc1
608   Ptare=Reddat(1,1)                 !REASSIGNMENT OF ARRAY ELEMENTS TO
609                                      !TO IDENTIFIABLE QUANTITIES USED IN
610                                      !SUBROUTINE CALCULATIONS.
611   Pcal=Reddat(1,2)
612   Pp=Reddat(1,3)
613   Ps=Reddat(1,4)
614   P1=Reddat(1,5)
615   P2=Reddat(1,6)
616   P3=Reddat(1,7)
617   P23=(P2+P3)/2
618   P4=Reddat(1,8)
619   P5=Reddat(1,9)
620   Ptp=Reddat(1,10)
621   Psp=Reddat(1,11)
622  !BLANK=Reddat(1,12)
623  !BLANK=Reddat(1,13)
624  !BLANK=Reddat(1,14)
625   Posit=Reddat(1,15)
626   Yaw=Reddat(1,16)
627   Temp=Reddat(1,17)
628   Pa=Reddat(1,18)
629   !CALCULATE BETA AND GAMMA COEFFICIENTS
630   CALL Bgcalc(Pa,P1,P23,P4,P5,Beta,Gamma)
631   !CALCULATE THE ENSEMBLE REFERENCE VALUES OF PPLENUM,PLENUM TEMP AND PA.
632  CALL Ensemble(Pp,Pinitial,Pa,Painitial,Temp,Tinitial,Ppavg,Paavg,Tempavg,N)
633   !CALCULATE Xvel AND Phi
634   CALL Xphicalc(Beta,Gamma,Xvel,X(*),Phi,P(*))
```

```
635   !CALCULATE Xref
636   CALL Xrefcalc(Pa,Pp,G,Xref)
637   !CALCULATE QREF AND VREF
638   CALL Qvrefcalc(Xref,Cp,Temp,G,Pp,Pa,Qref,Vref)
639   !CALCULATE VELOCITY AND MACH # AND Q
640   CALL Vmqcalc(Xvel,Cp,Temp,G,Vel,Mach,P1,Pa,Q)
641   ! CALCULATE THE INTEGRAND FOR THE AVDR EXPRESSION
642   CALL Kncalc(Pa,P1,Pp,Xvel,Xref,G,Yaw,Kn)
643   ! CALCULATE THE COEFFICIENT OF PRESSURE TERMS TO BE MASS AVERAGED.
644   ! THESE TERMS ARE USED IN THE CALCULATION OF THE LOSS COEFFICIENT.
645   CALL Coefpress(P1,Pp,Pa,Xvel,G,Cps,Cpt)
646   !CALCULATE THE  QUANTITIES TO BE MASS AVERAGED. MULTIPLY THESE VALUES
647   !BY Kn TO GET THE INTEGRAND REQUIRED TO CALCULATE THE MASS AVERAGED CP'S
648   CALL Cpintegrand(Pp,P1,Pa,G,Xvel,A,B,Kn)
649   !CALCLULATE Pp-P1/Qref FOR PLOTS
650   CALL Prefqref(Pp,P1,Qref,Pq)
651   ! CALCULATE STATIC PRESSURE
652   CALL Staticpress(P1,Pa,Xvel,G,Ps)
653   !DEFINE AN ARRAY TO STORE CALCULATED VALUES
654   Calc(N,1)=Posit
655   Calc(N,2)=Beta
656   Calc(N,3)=Gamma
657   Calc(N,4)=Phi
658   Calc(N,5)=Xvel
659   Calc(N,6)=Xref
660   Calc(N,7)=Vel
661   Calc(N,8)=Mach
662   Calc(N,9)=Yaw
663   Calc(N,10)=Kn
664   Calc(N,11)=Cpt
665   Calc(N,12)=Cps
666   Calc(N,13)=Qref
667   Calc(N,14)=Vref
668   Calc(N,15)=Q
669   Calc(N,16)=A
670   Calc(N,17)=B
671   Calc(N,18)=Pq
672   Calc(N,19)=Pa
673   Calc(N,20)=Ps
674   Knaray(N)=Calc(N,10)                !WANT TO STORE THE Kn VALUE IN AN
675                                       !ARRAY FOR MASS AVERAGING CALCULATIONS
676   Prbpos(N)=Calc(N,1)                 !"" ""
677   Aaray(N)=Calc(N,16)                 !"" ""
678   Baray(N)=Calc(N,17)                 !"" ""
679   Scan=N
680   NEXT N
681 Printcalc1:   OFF END @Path1
682   !CALCULATE ENSEMBLE AVERAGE OF XREF
683   CALL Xrefensemble(Paavg,Ppavg,G,Xrefavg)
684   !CALCULATE ENSEMBLE AVERAGE OF VREF
685   CALL Vrefensemble(Xrefavg,Cp,Tempavg,Vrefavg)
686   !CALCULATE ENSEMBLE AVERAGE OF QREF
687   CALL Qrefensemble(Paavg,Ppavg,G,Xrefavg,Qrefavg)
688   PRINT "************************************************************"
689   PRINT ""
690   PRINT "ALIGN PAPER IN THE PRINTER. WHEN READY FOR A HARDCOPY OF THE "
691   PRINT ""
692   PRINT "CALCULATED DATA, PRESS ""REDUCED DATA"" ."
693   PRINT ""
694   PRINT "**************************************************************"
695   ON KEY 4 LABEL "REDUCED DATA" GOTO Prntdata1
696 Spin3:   GOTO Spin3
697 Prntdata1:   PRINTER IS Prnter
698   PRINT "******************************************"
699   PRINT "FILE   ",Calcfile$
700   PRINT "******************************************"
```

```
701   PRINT ""
702   PRINT "*************************************************************
************"
703   PRINT ""
704   PRINT "SCAN   PRB       BETA          GAMMA         PHI            Xvel
 Xref"
705   PRINT "        POSIT"
706   FOR N=1 TO Scan
707   PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE
";N,Calc(N,1),Calc(N,2),Calc(N,3),Calc(N,4),Calc(N,5),Calc(N,6)
708   NEXT N
709   PRINT ""
710   PRINT "*************************************************************
************"
711   PRINT ""
712   PRINT "SCAN   Vel          Vref          Q              Qref          MACH
   YAW"
713   PRINT "
   DEG  "
714   FOR N=1 TO Scan
715   PRINT USING "4D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3D
E";N,Calc(N,7),Calc(N,14),Calc(N,15),Calc(N,13),Calc(N,8),Calc(N,9)
716   NEXT N
717   PRINT ""
718   PRINT "*************************************************************
************"
719   PRINT ""
720   PRINT "SCAN   Pref-Pt/Qref"
721   FOR N=1 TO Scan
722   PRINT USING "4D,3X,MD.3DE";N,Calc(N,18)
723   NEXT N
724   PRINT ""
725   PRINT "*************************************************************
************"
726   PRINT ""
727   PRINT " ENSEMBLE AVERAGES"
728   PRINT ""
729   PRINT "PPAVG           PAAVG           TEMPAVG     XREFAVG        VREFAVG
  QREFAVG"
730   PRINT USING "MD.3DE,5X,M3D.2DE,5X,3D.2D,5X,MD.3DE,5X,MD.3DE,3X,MD.3DE";Ppa
vg,Paavg,Tempavg,Xrefavg,Vrefavg,Qrefavg
731   PRINTER IS Scren
732   OUTPUT @Path4;Calc(*)                      !SERIAL OUTPUT STATEMENT.
733   END IF
734   PRINT "*************************************************************"
735   PRINT ""
736   PRINT "TO CALCULATE THE CP'S FOR THE BLADE DATA, PRESS ""BLADE CP'S"""
737   PRINT " PRESS ""GO ON"" TO CONTINUE."
738   PRINT ""
739   PRINT "*************************************************************
"
740   ON KEY 1 LABEL "BLADE   CP'S" GOTO Calculatecp
741   ON KEY 4 LABEL "GO ON" GOTO Loadoption2
742 Spin4:   GOTO Spin4
743 Calculatecp:   MASS STORAGE IS "/CLASSICK/REDDATA"
744   PRINT ""
745   PRINT "*********************************************************"
746   PRINT ""
747   PRINT "ENTER THE FILE NAME OF THE BLADE DATA SCALED IN ENGINEERING UNITS"
748   INPUT Sclbladfile$
749   PRINT "*************************************************************"
750   ASSIGN @Path5 TO Sclbladfile$
751   PRINT ""
752   PRINT "ENTER THE FILE NAME TO STORE THE MASS AVERAGED CP'S CALCULATED"
753   PRINT "FROM THE BLADE DATA."
754   INPUT Bladcalc$
```

```
755   CREATE BDAT Bladcalc$,100
756   ASSIGN @Path6 TO Bladcalc$
757   DIM Prntdata(1,48)            !DIMENSION STAIMENTS FOR BLADE ARRAYS
758                                 !ARE HERE SO ARRAY SPACE IS ONLY ASSIGNED
759                                 !IF BLADE OPTION IS SELECTED.
760   DIM Cpmassavg(48)
761   MAT Cpmassavg= (0)
762   MAT Prntdata= (0)
763   PRINT "*******************************************************"
764   PRINT ""
765   PRINT "ENTER THE LIMITS OF INTEGRATION i.e., THE LOWEST TO THE "
766   PRINT "HIGHEST SCAN NUMBER DESIRED."
767   PRINT ""
768   PRINT "********************************************************"
769   PRINT ""
770   PRINT "********************************************************"
771   PRINT ""
772   PRINT "ENTER THE LOW SCAN"
773   INPUT Lowpoint
774   PRINT "********************************************************"
775   PRINT ""
776   PRINT "ENTER THE HIGH SCAN"
777   INPUT Hipoint
778   LOADSUB ALL FROM "/CLASSICK/ROUTINES/LOSSCALC"
779   !INTEGRATE A
780   CALL Datint(Lowpoint,Hipoint,Aaray(*),Prbpos(*),Aintg)
781   !INTEGRATE B
782   CALL Datint(Lowpoint,Hipoint,Baray(*),Prbpos(*),Bintg)
783   !INTEGRATE Kn
784   CALL Datint(Lowpoint,Hipoint,Knaray(*),Prbpos(*),Knintg)
785   Al=Aintg/Knintg
786   Bl=Bintg/Knintg
787   ENTER @Path5;Prntdata(*)
788   Pp=Prntdata(1,3)
789   FOR N=Firstbladeprt TO Lastbladeprt !OBTAINED FROM PORT ASSIGNMENT SHEET
790   Plocal=Prntdata(1,N)
791   CALL Cpcalc(Al,Bl,Pp,Plocal,C)
792   Cpmassavg(N)=C
793   NEXT N
794   PRINT "*********************************************************"
795   PRINT ""
796   PRINT "ALIGN PAPER IN PRINTER AND PRESS ""BLADE DATA"" FOR HARD COPY"
797   PRINT " OF BLADE MASS AVERAGED COEFFICIENTS OF PRESSURE."
798   PRINT ""
799   PRINT "**********************************************************"
800   ON KEY 1 LABEL "BLADE   DATA" GOTO Prntbladedata
801 Spin5:   GOTO Spin5
802 Prntbladedata:  PRINTER IS Prnter
803   PRINT "*************************************"
804   PRINT "BLADE CP FILE  ",Bladcalc$
805   PRINT "*************************************************************
************"
806   PRINT ""
807   PRINT "SCANIVALVE       MASS AVERAGED COEFFICIENT"
808   PRINT "PORT             OF PRESSURE        "
809   FOR N=Firstbladeprt TO Lastbladeprt
810   PRINT USING "2D,15X,MD.3DE";N,Cpmassavg(N)
811   NEXT N
812   OUTPUT @Path6;Cpmassavg(*)        !SERIAL OUTPUT STATEMENT
813 Loadoption2:  PRINTER IS Scren
814   PRINT "**********************************************************"
815   PRINT ""
816   PRINT "TO LOAD PROGRAM THAT CALCULATES THE AVDR AND LOSS COEFFICIENT,"
817   PRINT ""
818   PRINT "PRESS ""LOSS"".  PRESS ""GO ON"" TO TERMINATE THE PROGRAM."
819   PRINT ""
```

```
820   PRINT "****************************************************************"
821   ON KEY 1 LABEL "LOSS" GOTO Loadup2
822   ON KEY 4 LABEL "GO ON" GOTO Fin
823 Spin6:   GOTO Spin6
824 Loadup2: MASS STORAGE IS "/CLASSICK/PROGS"
825          LOAD "LOSS",10
826 Fin:  PRINT ""
827  PRINT "**********************************************************"
828  PRINT ""
829  PRINT "                END OF PROGRAM         "
830  PRINT ""
831  PRINT "**********************************************************"
832  END
```

B7.3 Reduction Program LOSS

```
10    !PROGRAM LOSS
20    !THIS PROGRAM USES VALUES FROM THE CALC ARRAYS GENERATED BY REDUCING
30    !SCALED DATA IN PROGRAM CALC. SUBROUTINES INTEGRATE THESE VALUES AND A
50    !STATIC PRESSURE RISE COEFFICIENT,AVDR & LOSS COEFFICIENT IS CALCULATED.
51    !MUCH OF THE CODING WAS PREVIOUSLY COMMENTED ON IN PROGRAM ACQUIRE AND
52    !PROGRAM CALC.
60    OPTION BASE 1
70    DIM Calcl(100,25)           !NOTE THAT u AND l DESIGNATORS DISTINGUISH
71                                !THOSE VALUES FROM UPPER SURVEY AND LOWER
72                                !SURVEY STATIONS RESPECTIVELY.
80    DIM Calcu(100,25)
90    DIM Positl(100)
100   DIM Positu(100)
110   DIM Kn(100)                 !SEE TABLE I OF CLASSICK THESIS Kn=K.
120   DIM Knu(100)
121   DIM Cpt(100)                !THESE VALUES PREVIOUSLY DEFINED IN "CALC"
122   DIM Cptu(100)
123   DIM Cps(100)
124   DIM Y(100)                  !AN INTERMEDIATE QUANTITY IN THE STATIC
125                               !PRESSURE RISE COEFFICIENT CALCULATION.
129   DIM Z(100)                  !"     "     "
131   DIM Cptxkn(100)             !COMBINED VALUES TO MAKE THE INTEGRATIONS
132   DIM Cptuxknu(100)           !MORE EXPLICIT TO THE PROGRAMMER.
133   DIM Cpsxkn(100)
134   DIM Yxkn(100)
135   DIM Zxknu(100)
136   MAT Calcl= (0)
137   MAT Calcu= (0)
138   MAT Positl= (0)
139   MAT Positu= (0)
140   MAT Kn= (0)
141   MAT Knu= (0)
142   MAT Cpt= (0)
143   MAT Cptu= (0)
144   MAT Cps= (0)
145   MAT Cptxkn= (0)
146   MAT Cptuxknu= (0)
147   MAT Cpsxkn= (0)
148   MAT Yxkn= (0)
149   MAT Zxknu= (0)
150   LOADSUB ALL FROM "/CLASSICK/ROUTINES/LOSSCALC"
151   MASS STORAGE IS "/CLASSICK/REDDATA"
152   PRINT "ENTER THE NAME OF THE FILE CONTAINING THE CALCULATED DATA FROM THE"
153   PRINT "LOWER PROBE"
154   PRINT "****************************************************************"
155   INPUT Calclfile$
156   ASSIGN @Pathl TO Calclfile$
157   ENTER @Pathl;Calcl(*)
158   FOR N=1 TO 100
159   Positl(N)=Calcl(N,1)
212   Kn(N)=Calcl(N,10)
213   Cpt(N)=Calcl(N,11)
214   Cps(N)=Calcl(N,12)
215   Pal=Calcl(N,19)
216   Psl=Calcl(N,20)
217   Ql=Calcl(N,15)
218   IF Ql=0 THEN Skipy           !PREVENTS A DIVISION BY ZERO IF THE
219                                !ARRAY IS NOT ENTIRELY FILLED WITH
220                                !NONZERO VALUES i.e., TOTAL DATA POINTS
222   Y(N)=(Pal-Psl)/Ql            !TAKEN DID NOT EQUAL 100.
224   Cptxkn(N)=Cpt(N)*Kn(N)
225   Cpsxkn(N)=Cps(N)*Kn(N)
226   Yxkn(N)=Y(N)*Kn(N)
227   NEXT N
```

```
231 Skipy:  PRINT "ENTER THE NAME OF THE FILE CONTAINING THE CALCULATED DATA FRO
M THE"
232   PRINT "UPPER PROBE"
233   PRINT "****************************************************************"
234  INPUT Calcufile$
235  ASSIGN @Path2 TO Calcufile$
236  ENTER @Path2;Calcu(*)
237  FOR N=1 TO 100
238  Positu(N)=Calcu(N,1)
239  Knu(N)=Calcu(N,10)
240  Cptu(N)=Calcu(N,11)
241  Pau=Calcu(N.19)
242  Psu=Calcu(N,20)
243  Qu=Calcu(N,15)
244  IF Qu=0 THEN Skipz                       !SAME REASON FOR STRUCTURE HERE
245  Z(N)=(Psu-Pau)/Qu                        !AS FOR Q1.
246  Cptuxknu(N)=Cptu(N)*Knu(N)
247  Zxknu(N)=Z(N)*Knu(N)
248  NEXT N
249 Skipz: PRINT ""
250  PRINT "ENTER THE LIMITS OF INTEGRATION FOR THE LOWER PROBE SURVEY"
251  PRINT ""
252  PRINT "****************************************************************"
253   INPUT "ENTER THE FIRST POINT",Lowpoint
254   INPUT "ENTER THE LAST POINT",Hipoint
255   ! CALL THE INTEGRATION ROUTINE
256   CALL Datint(Lowpoint,Hipoint,Kn(*),Posit(*),Denominator)
257   CALL Datint(Lowpoint,Hipoint,Cptxkn(*),Posit(*),Intega)
258   CALL Datint(Lowpoint,Hipoint,Cpsxkn(*),Posit(*),Integc)
259   CALL Datint(Lowpoint,Hipoint,Yxkn(*),Posit(*),Integy)
263   PRINT ""
264   PRINT "ENTER THE LIMITS OF INTEGRATION FOR THE UPPER PROBE SURVEY"
265   PRINT ""
266   PRINT "****************************************************************"
267  INPUT "ENTER THE FIRST POINT",Lowpoint
268  INPUT "ENTER THE LAST POINT",Hipoint
269  CALL Datint(Lowpoint,Hipoint,Knu(*),Positu(*),Numerator)
270  CALL Datint(Lowpoint,Hipoint,Cptuxknu(*),Positu(*),Integb)
271  CALL Datint(Lowpoint,Hipoint,Zxknu(*),Positu(*),Integz)
272  Cp2=(Integz/Denominator)+(Integy/Denominator)
273  Avdr=Numerator/Denominator
274  PRINT "STATIC PRESSURE RISE COEFFICIENT"
275  PRINT USING "MD.3DE";Cp2
276  PRINT ""
277   PRINT "AVDR"
278  PRINT USING "MD.3DE";Avdr
279  PRINT ""
280   W=(Intega-(1/Avdr)*(Integb))/(Intega-Integc)
281   PRINT "LOSS COEFFICIENT"
282   PRINT USING "MD.3DE";W
283   PRINT "************************************************************"
284   PRINT ""
285   PRINT "                 END OF PROGRAM"
286   PRINT ""
287   PRINT "************************************************************"
288   END
```

B7.4 Subprogram SUBACQUIRE

```
1     !FILE SUBACQUIRE
10    !THIS FILE CONTAINS THE SUBPROGRAMS FOR POSITIONING THE SCANIVALVE
20    !PORTS AND READING THE DVM.
720   SUB Scnvportposit(Scnv,Dp,Scnhmsvc,Scnstpsvc)   !THE STRUCTURE OF THIS
721                                     !SUBPROGRAM IS SIMILAR TO PREVIOUS
722                                     !ACQUISITION PROGRAMS WRITTEN AT THE
723                                     !TPL. SEE GEOPFARTH THESIS.
725     OPTION BASE 1
726     COM /Positvrbls/ Svc,Scn
727 Posit:OUTPUT Svc USING "#,K";Scnv
728     Z=SPOLL(Svc)
729     U=BINAND(Z,15)
730     V=SHIFT(Z,4)
731     T=BINAND(V,7)
732     P=10*T+U                        !P IS THE PRESENT PORT THAT THE
733                                     !SCANIVALVE IS ON.
735     CLEAR Svc
736     IF P=Dp THEN Retrn
737     IF P>Dp THEN
738       OUTPUT Scn USING "ZZ";Scnhmsvc  !HOME THE SCANIVALVE
739       CLEAR Scn
740       WAIT 4                          !ALLOW 4 SECONDS FOR THE HOME TO
741                                       !COMPLETE.
743       GOTO Posit
744     ELSE
745       OUTPUT Scn USING "ZZ";Scnstpsvc !STEP THE SCANIVALVE
746       CLEAR Scn
747       WAIT .1                         !WAIT 1/10 SEC BETWEEN STEPS
748       GOTO Posit
749     END IF
750 Retrn: SUBEND
751   SUB Readdvm(Dp,Chanlasign)
752     OPTION BASE 1
753     COM /Positvrbls/ Svc,Scn
754     COM /Readvrbls/ Scan,Dvm,Scanvb(1,48),Tempchnrd,Yawchnrd,Scnyawchn,Scnte
mpchn,Scnrdsvcb,Scanva(1,48),Scnrdsvca,Noofprbs,Yawchnrdu,Scnrdsvc
755     COM /Readvrbls/ Yawchnrdl,Scnyawchnu,Scnyawchnl,Maxdif
756     OUTPUT Scn USING "ZZ";Chanlasign   !CHANLASIGN TAKES ON THE VALUE
757                                        !ASSIGNED TO IT BY THE CALLING
758                                        !STATEMENT IN THE MAIN PROGRAM.
760     OUTPUT Dvm;F1r7m3a0h0t3            !STANDARD SETTING FOR THE DVM.
761                                        !SETS THE FUNCTIONS ON THE PANEL.
763 Sample:  DIM A(5)
764     MAT A= (0)
765     FOR I=1 TO 5                       !TAKE 5 READINGS AND STORE IN THE
766                                        !"A" ARRAY
768    TRIGGER Dvm
769       ENTER Dvm;A(I)
770       Avg=SUM(A)/I                     !AVERAGE THE 5 READINGS
771       Dev=A(I)-Avg
772       IF Dev>Maxdif THEN               !ERROR TRAP FOR SPURIOUS DVM READINGS
773       PRINT "SAMPLE EXCEEDED MAXIMUN DEVIATION ALLOWED-SAMPLE RETAKEN"
774       GOTO Sample
775       END IF
776       WAIT .3
777     NEXT I
778     IF Noofprbs=1 THEN Readone
779       IF Chanlasign=Scnrdsvcb THEN
780         Scanvb(1,Dp)=SUM(A)/5
781       ELSE
782         IF Chanlasign=Scnyawchnl THEN
783           Yawchnrdl=SUM(A)/5
784         ELSE
785           IF Chanlasign=Scnyawchnu THEN
786             Yawchnrdu=SUM(A)/5
```

```
787           ELSE
788             GOTO Tempread
789           END IF
790         END IF
791       END IF
792 Readone:IF Chanlasign=Scnrdsvc THEN
793       Scanvb(I,Dp)=SUM(A)/5
794     ELSE
795         IF Chanlasign=Scnyawchn THEN
796         Yawchnrd=SUM(A)/5
797       ELSE
798 Tempread: Tempchnrd=SUM(A)/5
799       END IF
800     END IF
801     IF Chanlasign=Scnrdsvca THEN Scanva(I,Dp)=SUM(A)/5
802 Retrn: CLEAR Scn
803    SUBEND
```

B7.5 Subprogram SUBCALC

```
1      !FILE SUBCALC
10     !THIS FILE CONTAINS ALL THE CALCULATION SUBROUTINES CALLED BY THE
20     !DATA REDUCTION PROGRAM CALC.
798    SUB Bgcalc(Pa,P1,P23,P4,P5,Beta,Gamma)
799    Beta=(P1-P23)/(P1+Pa)
800    Gamma=(P4-P5)/(P1-P23)
801    SUBEND
802    SUB Xphicalc(Beta,Gamma,Xvel,X(*),Phi,P(*))
803    OPTION BASE 1
804    DIM E(6)
805    DIM F(6)
806    MAT E= (0)
807    MAT F= (0)
808    FOR J=1 TO 6
809    E(J)=X(1,J)+X(2,J)*Gamma+X(3,J)*Gamma^2+X(4,J)*Gamma^3+X(5,J)*Gamma^4+X(6,
J)*Gamma^5
810    F(J)=P(1,J)+P(2,J)*Gamma+P(3,J)*Gamma^2+P(4,J)*Gamma^3+P(5,J)*Gamma^4+P(6,
J)*Gamma^5
811    NEXT J
812    Xvel=E(1)+E(2)*Beta+E(3)*Beta^2+E(4)*Beta^3+E(5)*Beta^4+E(6)*Beta^5
813    Phi=F(1)+F(2)*Beta+F(3)*Beta^2+F(4)*Beta^3+F(5)*Beta^4+F(6)*Beta^5
814    SUBEND
815    SUB Vmqcalc(Xvel,Cp,Temp,G,Vel,Mach,P1,Pa,Q)
816    Vel=Xvel*(2*Cp*778*32.174*Temp)^.5
817   Mach=(((Xvel^2)/(1-Xvel^2))*(2/(G-1)))^.5
818    Q=(P1+Pa)*(G/(G-1))*Xvel^2*((1-Xvel^2)^(1/(G-1)))
819    SUBEND
820    SUB Xrefcalc(Pa,Pp,G,Xref)
821    Xref=(1-(Pa/(Pp+Pa))^((G-1)/G))^.5
822    SUBEND
823    SUB Kncalc(Pa,P1,Pp,Xvel,Xref,G,Yaw,Kn)
824         Kn=((P1+Pa)/(Pp+Pa))*(Xvel/Xref)*(((1-Xvel^2)/(1-Xref^2))^(1/(G-1)))
*COS(Yaw)
825    SUBEND
826    SUB Coefpress(P1,Pp,Pa,Xvel,G,Cps,Cpt)
827    Cpt=(P1+Pa)/(Pp+Pa)
828    Cps=((P1+Pa)*((1-Xvel^2)^(G/(G-1))))/(Pp+Pa)
829    SUBEND
856    SUB Ensemble(Pp,Pinitial,Pa,Painitial,Temp,Tinitial,Ppavg,Paavg,Tempavg,N)
857    Ppe=Pp+Pinitial
858    Ppavg=Ppe/N
859    Pinitial=Ppe
860    Te=Temp+Tinitial
861    Tempavg=Te/N
862    Tinitial=Te
863    Pae=Pa+Painitial
864    Paavg=Pae/N
865    Painitial=Pae
866    SUBEND
```

```
867   SUB Xrefensemble(Paavg,Ppavg,G,Xrefavg)
868   Xrefavg=(1-((Paavg)/(Ppavg+Paavg))^((G-1)/G))^.5
869   SUBEND
870   SUB Vrefensemble(Xrefavg,Cp,Tempavg,Vrefavg)
871   Vrefavg=Xrefavg*(2*Cp*Tempavg*778*32.174)^.5
872   SUBEND
873   SUB Qrefensemble(Paavg,Ppavg,G,Xrefavg,Qrefavg)
874   Qrefavg=(Ppavg+Paavg)*(G/(G-1))*Xrefavg^2*(1-Xrefavg^2)^(1/(G-1))
875   SUBEND
876   SUB Qvrefcalc(Xref,Cp,Temp,G,Pp,Pa,Qref,Vref)
877   Vref=Xref*(2*Cp*778*32.174*Temp)^.5
878   Qref=(Pa+Pp)*(G/(G-1))*(Xref^2)*((1-Xref^2)^(1/(G-1)))
879   SUBEND
880   SUB Cpintegrand(Pp,P1,Pa,G,Xvel,A,B,Kn)
881   M=Pp/((P1+Pa)*(G/(G-1))*Xvel^2*((1-Xvel^2)^(1/(G-1))))
882   N1=(Pa/(P1+Pa))-((1-Xvel^2)^(G/(G-1)))
883   N2=(G/(G-1))*Xvel^2*((1-Xvel^2)^(1/(G-1)))
884   N=N1/N2
885   A=M*Kn
886   B=N*Kn
887   SUBEND
888   SUB Cpcalc(A1,B1,Pp,Plocal,C)
889   C=((Plocal/Pp)*A1)+B1
890   SUBEND
900   SUB Staticpress(P1,Pa,Xvel,G,Ps)
910   Ps=(P1+Pa)*(1-Xvel^2)^(G/(G-1))
920   SUBEND
930   SUB Prefqref(Pp,P1,Qref,Pq)
940   Pq=(Pp-P1)/Qref
950   SUBEND
```

B7.6 Subprogram LOSSCALC

```
1     !FILE LOSSCALC
10    !THIS SUBPROGRAM IS AN ADAPTATION OF SHREEVE'S INTEGRATION ROUTINE
20    !GIVEN IN APPENDIX B OF NPS-57SF73071A
272   SUB Datint(Lowpoint,Hipoint,D(*),Posit(*),Datint)
277   OPTION BASE 1
287   DIM A(100)
297   DIM B(100)
307   DIM C(100)
317   DIM Dint(100)
321   MAT A= (0)
322   MAT B= (0)
323   MAT C= (0)
324   MAT Dint= (0)
325   N=Hipoint-1
326   Nm1=N-1
327   FOR I=Lowpoint+1 TO N
337   A(I)=(1/(Posit(I+1)-Posit(I-1)))*(((D(I+1)-D(I))/(Posit(I+1)-Posit(I)))-((
D(I)-D(I-1))/(Posit(I)-Posit(I-1))))
347   B(I)=((D(I)-D(I-1))/(Posit(I)-Posit(I-1)))-((Posit(I)+Posit(I-1))*A(I))
357   C(I)=D(I)-(A(I)*Posit(I)^2)-(B(I)*Posit(I))
360   NEXT I
361   Datint=0
362   FOR I=Lowpoint+1 TO Nm1
363   Dint(I)=(A(I)+A(I+1))*(Posit(I+1)^3-Posit(I)^3)/6+(B(I)+B(I+1))*(Posit(I+1
)^2-Posit(I)^2)/4+(C(I)+C(I+1))*(Posit(I+1)-Posit(I))/2
364   Datint=Datint+Dint(I)
367   NEXT I
377   Dint(1)=A(2)*(Posit(2)^3-Posit(1)^3)/3+B(2)*(Posit(2)^2-Posit(1)^2)/2+C(2)
*(Posit(2)-Posit(1))
387   Dint(N)=A(N)*(Posit(N+1)^3-Posit(N)^3)/3+B(N)*(Posit(N+1)^2-Posit(N)^2)/2+
C(N)*(Posit(N+1)-Posit(N))
397   Datint=Datint+Dint(1)+Dint(N)
407   SUBEND
```

B7.7 Plot Program PREFPOREF

```
1     !PROGRAM PREFPOREF
2     !PROGRAM PLOTS PREF-PT/QREF VS PROBE POSITION
4     MASS STORAGE IS "/CLASSICK/REDDATA"
7     INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
10    ASSIGN @Path1 TO Calcdat$
11    OPTION BASE 1
12    DIM Calc(100,25)
17    MAT Calc= (0)
20    Scan=31
26    ENTER @Path1;Calc(*)
50    GINIT
60    PLOTTER IS CRT,"INTERNAL"
70    GRAPHICS ON
73    X_gdu_max=100*MAX(1,RATIO)
74    Y_gdu_max=100*MAX(1,1/RATIO)
75    LORG 6
76    FOR I=-.3 TO .3 STEP .1
77    MOVE X_gdu_max/2+I,Y_gdu_max
78    LABEL "Pref-Pt1/Qref VS PROBE DISPLACEMENT"
79    NEXT I
83    DEG
84    LDIR 90
85    MOVE 0,Y_gdu_max/2
86    LABEL "Pref-Pt1/Qref"
87    LDIR 0
88    MOVE X_gdu_max/2,.1*Y_gdu_max
89    CSIZE 3,1
91    LABEL "BLADE-TO-BLADE (in)"
92    VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94    FRAME
95    WINDOW 0,3,0,.7
96    AXES .1,.01,0,0,5,10,2
97    CLIP OFF
98    CSIZE 2.5,.5
99    LORG 6
100   FOR I=0 TO 3 STEP .5
101   MOVE I,-.01
102   LABEL USING "#,K";I
103   NEXT I
104   LORG 8
105   FOR I=1.0 TO 0 STEP -.1
106   MOVE -.01,I
107   LABEL USING "DD.DD";I
108   NEXT I
109   FOR K=1 TO Scan
113   PLOT Calc(K,1),Calc(K,18)
114   NEXT K
117   END
```

B7.8 Plot Program BETAPOSIT

```
1    !PROGRAM BETAPOSIT
2    !PROGRAM PLOTS BETA VS PROBE POSITION
4    MASS STORAGE IS "/CLASSICK/REDDATA"
7    INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
10   ASSIGN @Path1 TO Calcdat$
11   OPTION BASE 1
12   DIM Calc(100,25)
17   MAT Calc= (0)
20   Scan=31
26   ENTER @Path1;Calc(*)
50   GINIT
60   PLOTTER IS CRT,"INTERNAL"
70   GRAPHICS ON
73   X_gdu_max=100*MAX(1,RATIO)
74   Y_gdu_max=100*MAX(1,1/RATIO)
75   LORG 6
76   FOR I=-.3 TO .3 STEP .1
77   MOVE X_gdu_max/2+I,Y_gdu_max
78   LABEL "BETA1 VS PROBE DISPLACEMENT"
79   NEXT I
83   DEG
84   LDIR 90
85   MOVE 0,Y_gdu_max/2
86   LABEL "BETA1 (deg)"
87   LDIR 0
88   MOVE X_gdu_max/2,.1*Y_gdu_max
89   CSIZE 3,1
91   LABEL "BLADE-TO-BLADE (in)"
92   VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94   FRAME
95   WINDOW 0,3,-50,-45
96   AXES .1,.2,0,-50,5,5,2
97   CLIP OFF
98   CSIZE 2.5,.5
99   LORG 6
100  FOR I=0 TO 3 STEP .5
101  MOVE I,-50.2
102  LABEL USING "#,K";I
103  NEXT I
104  LORG 8
105  FOR I=-50.0 TO -45.0 STEP 1
106  MOVE -.01,I
107  LABEL USING "DDD.D";I
108  NEXT I
109  FOR K=1 TO Scan
113  PLOT Calc(K,1),-Calc(K,9)
114  NEXT K
117  END
```

B7.9 Plot Program VVREFSPAN

```
1     !PROGRAM VVREFSPAN
2     !PROGRAM PLOTS V1/VREF VS PROBE POSITION FOR A SPAN-WISE SURVEY
4     MASS STORAGE IS "/CLASSICK/REDDATA"
5     INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
6     ASSIGN @Path2 TO Calcdat$
9     OPTION BASE 1
10    DIM Calc(:30,25)
11    MAT Calc= (0)
12    Scan=42
14    ENTER @Path2;Calc(*)
50    GINIT
60    PLOTTER IS CRT,"INTERNAL"
70    GRAPHICS ON
73    X_gdu_max=100*MAX(1,RATIO)
74    Y_gdu_max=100*MAX(1,1/RATIO)
75    LORG 6
76    FOR I=-.3 TO .3 STEP .1
77    MOVE X_gdu_max/2+I,Y_gdu_max
78    LABEL "V1/Vref VS PROBE DISPLACEMENT"
79    NEXT I
83    DEG
84    LDIR 90
85    MOVE 0,Y_gdu_max/2
86    LABEL "V1/Vref"
87    LDIR 0
88    MOVE X_gdu_max/2,.1*Y_gdu_max
89    CSIZE 3,1
91    LABEL "SPAN (in) "
92    VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94    FRAME
95    WINDOW -5,5,1,1.5
96    AXES 1,.01,-5,1.0,1,10,2
97    CLIP OFF
98    CSIZE 2.5,.5
99    LORG 6
100   FOR I=5 TO -5 STEP -1
101   MOVE I,.99
102   LABEL USING "$,K";I
103   NEXT I
104   LORG 8
105   FOR I=15 TO 1.0 STEP -.1
106   MOVE -5.05,I
107   LABEL USING "DD.DD";I
108   NEXT I
109   FOR K=1 TO Scan
113   PLOT Calc(K,1),Calc(K,7)/Calc(K,14)
114   NEXT K
117   END
```

B7.10 Plot Program VVREFUSPAN

```
1     !PROGRAM VVREFUSPAN
2     !PROGRAM PLOTS V2/VREF VS PROBE POSITION FOR UPPER TRAVERSE SPAN-WISE
3     ! SURVEYS
5     MASS STORAGE IS "/CLASSICK/REDDATA"
6     INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
7     ASSIGN @Path2 TO Calcdat$
9     OPTION BASE 1
10    DIM Calc(100,25)
11    MAT Calc= (0)
12    Scan=38
14    ENTER @Path2;Calc(*)
50    GINIT
60    PLOTTER IS CRT,"INTERNAL"
70    GRAPHICS ON
73    X_gdu_max=100*MAX(1,RATIO)
74    Y_gdu_max=100*MAX(1,1/RATIO)
75    LORG 6
76    FOR I=-.3 TO .3 STEP .1
77    MOVE X_gdu_max/2+I,Y_gdu_max
78    LABEL "V2/Vref VS PROBE DISPLACEMENT"
79    NEXT I
83    DEG
84    LDIR 90
85    MOVE 0,Y_gdu_max/2
86    LABEL "V2/Vref"
87    LDIR 0
88    MOVE X_gdu_max/2,.1*Y_gdu_max
89    CSIZE 3,1
91    LABEL "SPAN (in) "
92    VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94    FRAME
95    WINDOW -5,5,.5,1.0
96    AXES 1,.01,-5,.5,1,10,2
97    CLIP OFF
98    CSIZE 2.5,.5
99    LORG 6
100   FOR I=5 TO -5 STEP -1
101   MOVE I,.49
102   LABEL USING "#,K";I
103   NEXT I
104   LORG 8
105   FOR I=1.0 TO .5 STEP -.1
106   MOVE -5.05,I
107   LABEL USING "DD.DD";I
108   NEXT I
109   FOR K=1 TO Scan
113   PLOT Calc(K,1),Calc(K,7)/Calc(K,14)
114   NEXT K
117   END
```

B7.11 Plot Program CPBLADEPLOT

```
1    !PROGRAM CPBLADEPLOT
2    !PROGRAM PLOTS MASS AVERAGED BLADE COEFFICIENT OF PRESSURE AGAINST
3    !THE FRACTION OF CORD X/C FROM THE LEADING EDGE.
5    MASS STORAGE IS "/CLASSICK/REDDATA"
7    INPUT "ENTER THE NAME OF THE FILE CONTAINING THE BLADE CP'S",Cpfile$
10   ASSIGN @Path1 TO Cpfile$
11   OPTION BASE 1
12   DIM Cpmassavg(40)
15   DIM Xoc(20)
16   MAT Cpmassavg= (0)
19   DATA 98.8,94.8,90.8,86.8,82.8,78.8,71.5,64.1,56.7,49.3,41.9,34.3,26.9,19.6
,12.2,8.6,4.8,3.2,1.6,0
20   READ Xoc(*)
26   ENTER @Path1;Cpmassavg(*)
54   GINIT
60   PLOTTER IS CRT,"INTERNAL"
70   GRAPHICS ON
73   X_gdu_max=100*MAX(1,RATIO)
74   Y_gdu_max=100*MAX(1,1/RATIO)
75   LORG 6
76   FOR I=-.3 TO .3 STEP .1
77   MOVE X_gdu_max/2+I,Y_gdu_max
78   LABEL "Cp VS PERCENT CHORD"
79   NEXT I
83   DEG
84   LDIR 90
85   MOVE 0,Y_gdu_max/2
86   LABEL "Cp"
87   LDIR 0
88   MOVE X_gdu_max/2,.1*Y_gdu_max
89   CSIZE 3,1
91   LABEL "X/C PERCENT CHORD"
92   VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94   FRAME
95   WINDOW 0,100,1.0,-1.6
96   AXES 5,.2,0,1.0,2,2,2
97   CLIP OFF
98   CSIZE 2.5,.5
99   LORG 6
100  FOR I=0 TO 100 STEP 10
101  MOVE I,1.02
102  LABEL USING "#,K";I
103  NEXT I
104  LORG 8
105  FOR I=-1.6 TO 1.0 STEP .4
106  MOVE -.6,I
107  LABEL USING "DD.DD";I
108  NEXT I
109  FOR N=1 TO 20
113  PLOT Xoc(N),Cpmassavg(N+3)
114  NEXT N
115  FOR N=1 TO 20
116  PLOT Xoc(21-N),Cpmassavg(22+N)
117  NEXT N
119  END
```

B7.12 Program CORRECT A

```
10    !PROGRAM CORRECT A
11    OPTION BASE 1
20    DIM Scldata(1,106)
30    DIM Correctaray(1,106)
35    MAT Correctaray= (0)
40    MAT Scldata= (0)
80    MASS STORAGE IS "/CLASSICK/REDDATA"
90    INPUT "ENTER THE NAME OF THE FILE TO BE CORRECTED",Sclfile$
100   INPUT "ENTER THE NAME OF THE CORRECTED FILE",Correctfile$
110   CREATE BDAT Correctfile$,500,848
120   ASSIGN @Path1 TO Sclfile$
130   ASSIGN @Path2 TO Correctfile$
140   FOR N=1 TO 49
150   ENTER @Path1,N;Scldata(*)
151   ON END @Path1 GOTO Adddata
153 Adddata:  IF N=49 THEN
154   Scldata(1,1)=2.000E-2
155   Scldata(1,2)=1.494E+1
156   Scldata(1,3)=1.256E+1
157   Scldata(1,4)=-6.520E+0
158   Scldata(1,5)=7.700E+0
159   Scldata(1,6)=-8.160E-1
160   Scldata(1,7)=-8.280E-1
161   Scldata(1,8)=-3.280E-1
162   Scldata(1,9)=-1.270E+0
163   Scldata(1,10)=1.075E+1
164   Scldata(1,11)=-7.200E+0
165   Scldata(1,12)=1.000E-2
166   Scldata(1,13)=-2.000E-3
167   Scldata(1,14)=-6.000E-3
168   Scldata(1,16)=1.770E+0
169   Scldata(1,15)=3.0
170   Scldata(1,17)=4.561E+2
171   Scldata(1,18)=405.20
172   END IF
173   MAT Correctaray= Scldata
174   OUTPUT @Path2,N;Correctaray(*)
175   NEXT N
192   ASSIGN @Path2 TO Correctfile$
194   FOR N=1 TO 49
195   ENTER @Path2,N;Correctaray(*)
197   PRINT "************"
198   PRINT "SCAN",N
200   PRINT Correctaray(*)
201   PRINT "*************"
203   NEXT N
210   END
```

B7.13 Program CORRECT B

```
10    !PROGRAM CORRECT B
11    OPTION BASE 1
20    DIM Scldata(1,106)
30    DIM Correctaray(1,106)
35    MAT Correctaray= (0)
40    MAT Scldata= (0)
80    MASS STORAGE IS "/CLASSICK/REDDATA"
90    INPUT "ENTER THE NAME OF THE FILE TO BE CORRECTED",Sclfile$
100   INPUT "ENTER THE NAME OF THE CORRECTED FILE",Correctfile$
110   CREATE BDAT Correctfile$,600,840
120   ASSIGN @Path1 TO Sclfile$
130   ASSIGN @Path2 TO Correctfile$
140   FOR N=1 TO 48
150   ENTER @Path1,N;Scldata(*)
151   IF N=35 THEN Scldata(1,15)=1.95
163   MAT Correctaray= Scldata
164   OUTPUT @Path2,N;Correctaray(*)
166   NEXT N
192   ASSIGN @Path2 TO Correctfile$
194   FOR N=1 TO 48
195   ENTER @Path2,N;Correctaray(*)
197   PRINT "*************"
199   PRINT "SCAN",N
200   PRINT Correctaray(*)
201   PRINT "**************"
203   NEXT N
210   END
```

B7.14 Program CORRECT C

```
10    !PROGRAM CORRECT C
11    OPTION BASE 1
20    DIM Scldata(1,106)
30    DIM Correctaray(1,108)
31    DIM Correctdata(30)
35    MAT Correctarey= (0)
40    MAT Scldata= (0)
50    DATA -3.2,-3.1,-3.0,-2.9,-2.8,-2.7,-2.6,-2.5,-2.4,-2.3,-2.2,-2.1,-2.0,-1.9
,-1.7, 1.5,-1.2,-1.1,-.7,-.5,-.2,.1,.4,.7,1.0,1.3,1.6,1.9,2.1,2.3,2.5,2.6,2.7
70    DATA 2.8,2.9,3.0;3.1,3.2
71    READ Correctdata(*)
80    MASS STORAGE IS "/CLASSICK/REDDATA"
90    INPUT "ENTER THE NAME OF THE FILE TO BE CORRECTED",Sclfile$
100   INPUT "ENTER THE NAME OF THE CORRECTED FILE",Correctfile$
110   CREATE BDAT Correctfile$,500,848
120   ASSIGN @Path1 TO Sclfile$
130   ASSIGN @Path2 TO Correctfile$
140   FOR N=1 TO 30
150   ENTER @Path1,N;Scldata(*)
151   Scldata(1,15)=Correctdata(N)
163   MAT Correctaray= Scldata
164   OUTPUT @Path2,N;Corractaray(*)
166   NEXT N
192   ASSIGN @Path2 TO Correctfile$
194   FOR N=1 TO 30
195   ENTER @Path2,N;Correctaray(*)
197   PRINT "*************"
198   PRINT "SCAN",N
200   PRINT Correctaray(*)
201   PRINT "**************"
203   NEXT N
210   END
```

B7.15 Program PRBCOEF

```
10    ! PROGRAM PRBCOEF
20    ! THIS PROGRAM STORES THE PROBE COEFFICIENTS IN A DATA FILE
30    OPTION BASE 1
40    DIM C(6,6)
50    DATA 1,2,3,4,5,0,2,3,4,5,6,0,3,4,5,6,7,0,4,5,6,7,8,0,0,0,0,0,0,0,0,0,0,0,0
,0
60    READ C(*)
70    PRINT C(*)
80    !STORE THE DATA INTO A FILE
90    MASS STORAGE IS "/CLASSICK/REDDATA"
100   INPUT "ENTER THE NAME OF THE COEFFICIENT FILE",Reddata$
110   CREATE BDAT Reddata$,1,400
120   ASSIGN @Path1 TO Reddata$
130   OUTPUT @Path1;C(*)
140   !PRINT STORED COEFFICIENT ARRAY
150   ASSIGN @Path1 TO Reddata$
160   ENTER @Path1;C(*)
161   FOR N=1 TO 6
162   PRINT USING "MD.3DE,4X";C(N,1),C(N,2),C(N,3),C(N,4),C(N,5),C(N,6)
163   NEXT N
165   END
```

B7.10 Examples of Acquired and Reduced Data

The Scanivalve port and scanner channel assignments for data acquired using program ACQUIRE are shown in Table B1.

An example of the table of survey data output by program ACQUIRE in engineering units ('scaled') is given in Table B2, and the corresponding reduced data output by program CALC is given in Table B3 for an upstream probe survey. Similar results for the downstream survey (survey # in Table II) are given in Table B4 and Table B5 respectively.

An example of scaled data output by program ACQUIRE for a surface pressure scan is given in Table B6. The corresponding table of pressure coefficients calculated by program CALC is given in Table B7.

B8. FLEXIBLE DISC INITIALIZATION AND FILE BACKUP

Flexible discs are used to backup the files stored on the computer's hard disc. The file structure used for the present work was designed to allow the contents of each subdirectory to be stored separately from the other subdirectories. Backing up the file system therefore requires separate flexible discs for each subdirectory. Blank discs must be formatted first, using the following steps:

1. Type MSI "/" [Puts system in root directory if not already there.]

TABLE B1. SCANIVALVE PORT AND SCANNER CHANNEL ASSIGNMENTS

	5-Hole Probe S.V. # 2	S.V. # 1	ch	SCANNER #2	ch	SCANNER #2
1	P atmospheric	P atmospheric	0	SV1 READ DATA	40	SV1 ADVANCE(step)
2	P calibration	P calibration	1	SV2 " "	41	SV2 "
3	P plenum	P plenum	2		42	
4	P wall static	20B blade(press)	3		43	
5	P1 (probe)	19B	4		44	
6	P2 "	18B	5		45	SV1 RESET(home)
7	P3 "	17B	6		46	SV2 "
8	P4 "	16B	7		47	
9	P5 "	15B	8		48	
10	Ptp Prandtl(total)	14B	9		49	
11	Psp Prandtl(static)	13B	10	Tt(plenum)	50	
12	BLANK	12B	11		51	
13	"	11B	12		52	
14	"	10B	13		53	
15		9B	14		54	
16		8B	15		55	
17		7B	16		56	
18		6B	17		57	
19		5B	18		58	
20		4B	19		59	
21		3B	20		60	
22		2B	21		61	
23		1	22		62	
24		2T(suction side)	23		63	
25		3T	24	YAW XDUCER	64	
26		4T	25		65	
27		5T	26		66	
28		6T	27		67	
29		7T	28		68	
30		8T	29		69	
31		9T	30		70	
32		10T	31		71	
33		11T	32		72	
34		12T	33		73	
35		13T	34		74	
36		14T	35		75	
37		15T	36		76	
38		16T	37		77	
39		17T	38		78	
40		18T	39		79	
41		19T				
42		20T				
43		S1 (partial inst)				
44		S2 (suction side)				
45		S3				
46		P2 (press side)				
47		P3				
48		TRAILING EDGE				

TABLE B2. UPSTREAM BLADE-TO-BLADE SCALED PROBE DATA FILE L-4SEPASCL

SCAN	PROBE POSIT	1	2	3	4	5
1	0.00	2.800E-02	1.475E+01	1.177E+01	-6.012E+00	1.010E+01
2	.10	3.400E-02	1.478E+01	1.182E+01	-6.052E+00	1.014E+01
3	.20	2.600E-02	1.478E+01	1.189E+01	-6.148E+00	1.019E+01
4	.30	2.600E-02	1.480E+01	1.187E+01	-6.104E+00	1.017E+01
5	.40	3.200E-02	1.479E+01	1.186E+01	-6.154E+00	1.015E+01
6	.50	2.400E-02	1.464E+01	1.195E+01	-6.112E+00	1.021E+01
7	.60	3.600E-02	1.482E+01	1.197E+01	-6.134E+00	1.027E+01
8	.70	2.400E-02	1.483E+01	1.200E+01	-6.156E+00	1.026E+01
9	.80	2.600E-02	1.484E+01	1.203E+01	-6.166E+00	1.025E+01
10	.90	4.200E-02	1.485E+01	1.201E+01	-6.218E+00	1.028E+01
11	1.00	3.400E-02	1.487E+01	1.203E+01	-6.180E+00	1.024E+01
12	1.10	3.800E-02	1.488E+01	1.209E+01	-6.246E+00	1.028E+01
13	1.20	4.800E-02	1.490E+01	1.212E+01	-6.282E+00	1.025E+01
14	1.30	3.400E-02	1.491E+01	1.215E+01	-6.284E+00	1.027E+01
15	1.40	3.200E-02	1.489E+01	1.219E+01	-6.334E+00	1.032E+01
16	1.50	3.600E-02	1.492E+01	1.225E+01	-6.266E+00	1.036E+01
17	1.60	3.600E-02	1.491E+01	1.225E+01	-6.358E+00	1.037E+01
18	1.70	3.400E-02	1.494E+01	1.230E+01	-6.280E+00	1.047E+01
19	1.80	3.600E-02	1.493E+01	1.233E+01	-6.356E+00	1.048E+01
20	1.90	4.200E-02	1.493E+01	1.232E+01	-6.388E+00	1.044E+01
21	2.00	4.400E-02	1.492E+01	1.235E+01	-6.374E+00	1.049E+01
22	2.10	4.000E-02	1.492E+01	1.247E+01	-6.490E+00	1.052E+01
23	2.20	4.200E-02	1.493E+01	1.249E+01	-6.420E+00	1.051E+01
24	2.30	3.400E-02	1.492E+01	1.262E+01	-6.518E+00	1.059E+01
25	2.40	4.800E-02	1.489E+01	1.266E+01	-6.574E+00	1.059E+01
26	2.50	3.600E-02	1.490E+01	1.273E+01	-6.588E+00	1.059E+01
27	2.60	4.000E-02	1.466E+01	1.276E+01	-6.582E+00	1.060E+01
28	2.70	4.200E-02	1.490E+01	1.276E+01	-6.586E+00	1.058E+01
29	2.80	4.600E-02	1.490E+01	1.278E+01	-6.620E+00	1.056E+01
30	2.90	4.600E-02	1.488E+01	1.277E+01	-6.632E+00	1.055E+01
31	3.00	4.600E-02	1.489E+01	1.279E+01	-6.680E+00	1.059E+01

SCAN	6	7	8	9	10	11
1	-7.496E+00	-7.542E+00	-6.816E+00	-8.432E+00	1.014E+01	-6.746E+00
2	-7.516E+00	-7.542E+00	-6.816E+00	-8.500E+00	1.021E+01	-6.798E+00
3	-7.576E+00	-7.602E+00	-6.750E+00	-6.578E+00	1.029E+01	-6.794E+00
4	-7.558E+00	-7.542E+00	-6.706E+00	-8.612E+00	1.025E+01	-6.782E+00
5	-7.566E+00	-7.578E+00	-6.620E+00	-8.680E+00	1.025E+01	-6.814E+00
6	-7.592E+00	-7.596E+00	-6.662E+00	-6.714E+00	1.028E+01	-6.620E+00
7	-7.594E+00	-7.612E+00	-6.650E+00	-6.816E+00	1.032E+01	-5.822E+00
8	-7.626E+00	-7.626E+00	-6.596E+00	-8.680E+00	1.036E+01	-6.816E+00
9	-7.630E+00	-7.640E+00	-6.562E+00	-8.862E+00	1.035E+01	-6.860E+00
10	-7.640E+00	-7.662E+00	-6.586E+00	-8.862E+00	1.034E+01	-6.850E+00
11	-7.670E+00	-7.626E+00	-6.592E+00	-8.920E+00	1.042E+01	-6.904E+00
12	-7.656E+00	-7.698E+00	-6.684E+00	-8.914E+00	1.044E+01	-6.898E+00
13	-7.682E+00	-7.696E+00	-6.670E+00	-8.870E+00	1.043E+01	-6.922E+00
14	-7.674E+00	-7.686E+00	-6.694E+00	-8.834E+00	1.048E+01	-6.924E+00
15	-7.714E+00	-7.700E+00	-6.764E+00	-8.816E+00	1.053E+01	-6.974E+00
16	-7.766E+00	-7.758E+00	-6.834E+00	-8.804E+00	1.055E+01	-7.008E+00
17	-7.726E+00	-7.726E+00	-6.892E+00	-8.842E+00	1.057E+01	-7.050E+00
18	-7.744E+00	-7.772E+00	-6.896E+00	-8.876E+00	1.060E+01	-7.042E+00
19	-7.788E+00	-7.772E+00	-6.970E+00	-8.826E+00	1.062E+01	-7.056E+00
20	-7.732E+00	-7.776E+00	-6.920E+00	-8.822E+00	1.061E+01	-7.102E+00
21	-7.788E+00	-7.776E+00	-6.950E+00	-8.886E+00	1.065E+01	-7.076E+00
22	-7.818E+00	-7.840E+00	-6.984E+00	-8.876E+00	1.073E+01	-7.146E+00
23	-7.842E+00	-7.842E+00	-6.970E+00	-8.978E+00	1.079E+01	-7.172E+00
24	-7.914E+00	-7.930E+00	-7.062E+00	-9.086E+00	1.092E+01	-7.250E+00
25	-7.960E+00	-7.932E+00	-7.040E+00	-9.140E+00	1.092E+01	-7.220E+00
26	-7.946E+00	-7.958E+00	-6.974E+00	-9.158E+00	1.096E+01	-7.284E+00
27	-7.976E+00	-7.988E+00	-6.912E+00	-9.220E+00	1.096E+01	-7.310E+00
28	-7.968E+00	-7.990E+00	-6.936E+00	-9.256E+00	1.099E+01	-7.304E+00
29	-7.936E+00	-8.006E+00	-6.852E+00	-9.274E+00	1.103E+01	-7.318E+00
30	-7.964E+00	-7.976E+00	-6.836E+00	-9.326E+00	1.098E+01	-7.324E+00
31	-7.988E+00	-8.004E+00	-6.886E+00	-9.336E+00	1.107E+01	-7.386E+00

TABLE B2 (CONT.). UPSTREAM BLADE-TO-BLADE SCALED PROBE DATA FILE L-4SEPASCL

SCAN	12	13	14	YAW DEG	TEMP (R)	ATMOS PRESS
1	-6.000E-03	-1.660E-01	-2.460E-01	4.892E+01	4.607E+02	405.47
2	0.000E+00	-1.680E-01	-2.620E-01	4.870E+01	4.603E+02	405.47
3	0.000E+00	-1.680E-01	-2.620E-01	4.867E+01	4.602E+02	405.47
4	2.000E-03	-1.800E-01	-2.620E-01	4.865E+01	4.600E+02	405.47
5	6.000E-03	-1.840E-01	-2.580E-01	4.866E+01	4.596E+02	405.47
6	-4.000E-03	-1.660E-01	-2.600E-01	4.867E+01	4.597E+02	405.47
7	-8.000E-03	-1.660E-01	-2.560E-01	4.866E+01	4.596E+02	405.47
8	1.600E-02	-1.760E-01	-2.480E-01	4.866E+01	4.594E+02	405.47
9	1.800E-02	-1.500E-01	-2.520E-01	4.867E+01	4.595E+02	405.47
10	-1.400E-02	-1.840E-01	-2.620E-01	4.866E+01	4.596E+02	405.47
11	2.000E-03	-1.660E-01	-2.520E-01	4.866E+01	4.595E+02	405.47
12	-2.000E-03	-1.780E-01	-2.620E-01	4.865E+01	4.594E+02	405.47
13	-1.600E-02	-2.020E-01	-2.840E-01	4.867E+01	4.593E+02	405.47
14	-1.000E-02	-1.760E-01	-2.580E-01	4.867E+01	4.595E+02	405.47
15	4.000E-03	-1.900E-01	-2.420E-01	4.865E+01	4.593E+02	405.47
16	2.000E-03	-1.960E-01	-2.620E-01	4.865E+01	4.592E+02	405.47
17	8.000E-03	-1.660E-01	-2.660E-01	4.867E+01	4.593E+02	405.47
18	1.200E-02	-1.620E-01	-2.680E-01	4.864E+01	4.593E+02	405.47
19	4.000E-03	-1.780E-01	-2.580E-01	4.866E+01	4.590E+02	405.47
20	6.000E+00	-1.780E-01	-2.660E-01	4.830E+01	4.594E+02	405.47
21	4.000E-03	-1.840E-01	-2.740E-01	4.865E+01	4.594E+02	405.47
22	1.800E-02	-1.700E-01	-2.500E-01	4.866E+01	4.595E+02	405.47
23	4.000E-03	-1.920E-01	-2.760E-01	4.864E+01	4.598E+02	405.47
24	2.000E-03	-1.820E-01	-2.540E-01	4.875E+01	4.601E+02	405.47
25	6.939E-18	-1.720E-01	-2.620E-01	4.866E+01	4.603E+02	405.47
26	1.400E-02	-1.820E-01	-2.480E-01	4.865E+01	4.603E+02	405.47
27	6.000E-03	-1.740E-01	-2.400E-01	4.865E+01	4.603E+02	405.47
28	2.000E-03	-1.860E-01	-2.560E-01	4.867E+01	4.602E+02	405.47
29	0.000E+00	-1.740E-01	-2.500E-01	4.863E+01	4.604E+02	405.47
30	2.000E-03	-1.960E-01	-2.700E-01	4.864E+01	4.607E+02	405.47
31	-2.000E-03	-1.860E-01	-2.560E-01	4.879E+01	4.606E+02	405.47

TABLE B3. UPSTREAM BLADE-TO-BLADE REDUCED PROBE DATA FILE L-4SEPACALC

SCAN	PRB POSIT	BETA	GAMMA	PHI	Xvel	Xref
1	0.00	4.240E-02	9.172E-02	-1.550E-03	1.092E-01	9.023E-02
2	.10	4.252E-02	9.529E-02	-3.445E-03	1.093E-01	9.044E-02
3	.20	4.277E-02	1.028E-01	-7.483E-03	1.096E-01	9.068E-02
4	.30	4.263E-02	1.076E-01	-1.012E-02	1.093E-01	9.061E-02
5	.40	4.263E-02	1.163E-01	-1.492E-02	1.092E-01	9.057E-02
6	.50	4.283E-02	1.153E-01	-1.433E-02	1.095E-01	9.091E-02
7	.60	4.299E-02	1.212E-01	-1.759E-02	1.096E-01	9.098E-02
8	.70	4.306E-02	1.276E-01	-2.116E-02	1.097E-01	9.108E-02
9	.80	4.303E-02	1.275E-01	-2.111E-02	1.096E-01	9.119E-02
10	.90	4.312E-02	1.270E-01	-2.081E-02	1.097E-01	9.113E-02
11	1.00	4.304E-02	1.301E-01	-2.260E-02	1.096E-01	9.121E-02
12	1.10	4.320E-02	1.242E-01	-1.923E-02	1.099E-01	9.145E-02
13	1.20	4.316E-02	1.226E-01	-1.836E-02	1.099E-01	9.153E-02
14	1.30	4.318E-02	1.192E-01	-1.646E-02	1.099E-01	9.164E-02
15	1.40	4.335E-02	1.139E-01	-1.345E-02	1.102E-01	9.182E-02
16	1.50	4.358E-02	1.087E-01	-1.056E-02	1.106E-01	9.203E-02
17	1.60	4.353E-02	1.077E-01	-1.003E-02	1.105E-01	9.203E-02
18	1.70	4.383E-02	1.083E-01	-1.029E-02	1.109E-01	9.219E-02
19	1.80	4.389E-02	1.017E-01	-6.635E-03	1.111E-01	9.233E-02
20	1.90	4.375E-02	1.045E-01	-8.234E-03	1.109E-01	9.229E-02
21	2.00	4.394E-02	1.060E-01	-9.034E-03	1.111E-01	9.240E-02
22	2.10	4.411E-02	1.031E-01	-7.393E-03	1.114E-01	9.283E-02
23	2.20	4.412E-02	1.094E-01	-1.087E-02	1.113E-01	9.291E-02
24	2.30	4.450E-02	1.093E-01	-1.077E-02	1.118E-01	9.338E-02
25	2.40	4.455E-02	1.133E-01	-1.297E-02	1.118E-01	9.352E-02
26	2.50	4.457E-02	1.178E-01	-1.546E-02	1.118E-01	9.377E-02
27	2.60	4.466E-02	1.242E-01	-1.905E-02	1.118E-01	9.388E-02
28	2.70	4.462E-02	1.250E-01	-1.949E-02	1.118E-01	9.388E-02
29	2.80	4.461E-02	1.305E-01	-2.263E-02	1.117E-01	9.397E-02
30	2.90	4.451E-02	1.348E-01	-2.507E-02	1.115E-01	9.391E-02
31	3.00	4.467E-02	1.318E-01	-2.336E-02	1.117E-01	9.400E-02

SCAN	Vel	Vref	Q	Qref	MACH	YAW DEG
1	2.568E+02	2.123E+02	1.682E+01	1.165E+01	2.455E-01	4.892E+01
2	2.570E+02	2.127E+02	1.686E+01	1.170E+01	2.459E-01	4.870E+01
3	2.576E+02	2.132E+02	1.695E+01	1.177E+01	2.465E-01	4.867E+01
4	2.570E+02	2.130E+02	1.687E+01	1.175E+01	2.459E-01	4.865E+01
5	2.566E+02	2.128E+02	1.684E+01	1.174E+01	2.457E-01	4.866E+01
6	2.573E+02	2.136E+02	1.692E+01	1.183E+01	2.463E-01	4.867E+01
7	2.576E+02	2.138E+02	1.697E+01	1.185E+01	2.467E-01	4.866E+01
8	2.576E+02	2.140E+02	1.697E+01	1.187E+01	2.467E-01	4.866E+01
9	2.575E+02	2.143E+02	1.696E+01	1.190E+01	2.466E-01	4.867E+01
10	2.579E+02	2.142E+02	1.700E+01	1.189E+01	2.469E-01	4.866E+01
11	2.575E+02	2.143E+02	1.695E+01	1.191E+01	2.465E-01	4.866E+01
12	2.581E+02	2.148E+02	1.704E+01	1.197E+01	2.472E-01	4.865E+01
13	2.581E+02	2.150E+02	1.703E+01	1.199E+01	2.471E-01	4.867E+01
14	2.583E+02	2.153E+02	1.705E+01	1.202E+01	2.473E-01	4.867E+01
15	2.589E+02	2.157E+02	1.715E+01	1.207E+01	2.480E-01	4.865E+01
16	2.598E+02	2.162E+02	1.727E+01	1.212E+01	2.488E-01	4.865E+01
17	2.597E+02	2.162E+02	1.725E+01	1.212E+01	2.487E-01	4.867E+01
18	2.606E+02	2.166E+02	1.737E+01	1.217E+01	2.496E-01	4.864E+01
19	2.609E+02	2.168E+02	1.742E+01	1.220E+01	2.500E-01	4.866E+01
20	2.605E+02	2.168E+02	1.735E+01	1.219E+01	2.495E-01	4.865E+01
21	2.611E+02	2.171E+02	1.743E+01	1.222E+01	2.500E-01	4.865E+01
22	2.617E+02	2.181E+02	1.751E+01	1.234E+01	2.506E-01	4.866E+01
23	2.616E+02	2.184E+02	1.749E+01	1.236E+01	2.505E-01	4.864E+01
24	2.629E+02	2.196E+02	1.765E+01	1.248E+01	2.516E-01	4.875E+01
25	2.630E+02	2.199E+02	1.765E+01	1.252E+01	2.517E-01	4.866E+01
26	2.629E+02	2.205E+02	1.764E+01	1.259E+01	2.516E-01	4.865E+01
27	2.630E+02	2.208E+02	1.765E+01	1.262E+01	2.517E-01	4.865E+01
28	2.628E+02	2.207E+02	1.763E+01	1.262E+01	2.515E-01	4.867E+01
29	2.626E+02	2.210E+02	1.760E+01	1.264E+01	2.513E-01	4.863E+01
30	2.623E+02	2.209E+02	1.754E+01	1.263E+01	2.508E-01	4.864E+01
31	2.629E+02	2.211E+02	1.762E+01	1.265E+01	2.514E-01	4.879E+01

TABLE B3 (CONT.). UPSTREAM BLADE-TO-BLADE REDUCED PROBE DATA FILE L-4SEPACALC

SCAN	Pref-Pt/Qref
1	1.432E-01
2	1.436E-01
3	1.445E-01
4	1.449E-01
5	1.459E-01
6	1.473E-01
7	1.435E-01
8	1.447E-01
9	1.491E-01
10	1.459E-01
11	1.502E-01
12	1.514E-01
13	1.553E-01
14	1.561E-01
15	1.557E-01
16	1.561E-01
17	1.549E-01
18	1.499E-01
19	1.521E-01
20	1.544E-01
21	1.522E-01
22	1.579E-01
23	1.604E-01
24	1.626E-01
25	1.655E-01
26	1.698E-01
27	1.712E-01
28	1.731E-01
29	1.762E-01
30	1.758E-01
31	1.742E-01

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ENSEMBLE AVERAGES

PPAVG	PAAVG	TEMPAVG	XREFAVG	VREFAVG	QREFAVG
1.227E+01	405.47E+00	459.78	9.210E-02	2.165E+02	1.214E+01

TABLE B4. DOWNSTREAM BLADE-TO-BLADE SCALED PROBE DATA FILE U-SEPASCL

SCAN	PROBE POSIT	1	2	3	4	5	6	7
1	0.00	3.200E-02	1.498E+01	1.088E+01	-5.584E+00	6.946E+00	-6.880E-01	-6.920E-01
2	.10	2.600E-02	1.501E+01	1.081E+01	-5.626E+00	6.648E+00	-6.700E-01	-6.840E-01
3	.20	3.800E-02	1.499E+01	1.074E+01	-5.614E+00	5.954E+00	-6.440E-01	-6.680E-01
4	.30	3.000E-02	1.501E+01	1.074E+01	-5.602E+00	5.504E+00	-6.280E-01	-6.280E-01
5	.40	3.800E-02	1.498E+01	1.072E+01	-5.576E+00	5.058E+00	-6.080E-01	-6.080E-01
6	.50	4.200E-02	1.499E+01	1.072E+01	-5.568E+00	4.788E+00	-5.940E-01	-5.940E-01
7	.55	4.400E-02	1.497E+01	1.071E+01	-5.550E+00	4.738E+00	-6.020E-01	-6.120E-01
8	.60	3.600E-02	1.500E+01	1.070E+01	-5.576E+00	4.728E+00	-6.000E-01	-6.120E-01
9	.65	4.800E-02	1.501E+01	1.068E+01	-5.548E+00	4.720E+00	-6.340E-01	-6.400E-01
10	.70	4.400E-02	1.500E+01	1.069E+01	-5.490E+00	4.836E+00	-6.300E-01	-6.520E-01
11	.75	3.600E-02	1.500E+01	1.072E+01	-5.574E+00	4.968E+00	-6.300E-01	-6.660E-01
12	.80	4.400E-02	1.498E+01	1.073E+01	-5.588E+00	5.160E+00	-6.880E-01	-6.740E-01
13	.85	4.000E-02	1.501E+01	1.105E+01	-5.784E+00	5.512E+00	-7.200E-01	-7.300E-01
14	.90	4.000E-02	1.499E+01	1.128E+01	-5.824E+00	5.878E+00	-7.780E-01	-7.580E-01
15	.95	3.400E-02	1.502E+01	1.138E+01	-5.926E+00	6.276E+00	-8.020E-01	-7.960E-01
16	1.00	3.200E-02	1.500E+01	1.156E+01	-6.006E+00	6.660E+00	-8.020E-01	-8.260E-01
17	1.05	2.800E-02	1.508E+01	1.163E+01	-5.972E+00	7.066E+00	-8.220E-01	-8.300E-01
18	1.10	4.200E-02	1.509E+01	1.170E+01	-6.064E+00	7.492E+00	-8.680E-01	-8.760E-01
19	1.15	4.000E-02	1.507E+01	1.174E+01	-6.108E+00	7.822E+00	-8.720E-01	-8.900E-01
20	1.20	4.400E-02	1.505E+01	1.180E+01	-6.116E+00	8.214E+00	-8.760E-01	-8.880E-01
21	1.25	3.400E-02	1.504E+01	1.187E+01	-6.118E+00	8.550E+00	-9.020E-01	-8.840E-01
22	1.30	3.000E-02	1.503E+01	1.190E+01	-6.180E+00	8.828E+00	-8.820E-01	-8.860E-01
23	1.35	4.800E-02	1.503E+01	1.191E+01	-6.176E+00	9.130E+00	-8.880E-01	-8.960E-01
24	1.40	5.600E-02	1.499E+01	1.186E+01	-6.156E+00	9.238E+00	-8.900E-01	-8.820E-01
25	1.45	4.200E-02	1.500E+01	1.192E+01	-6.154E+00	9.468E+00	-8.640E-01	-8.740E-01
26	1.50	4.600E-02	1.498E+01	1.191E+01	-6.172E+00	9.624E+00	-8.540E-01	-8.680E-01
27	1.55	3.600E-02	1.501E+01	1.197E+01	-6.208E+00	9.748E+00	-8.480E-01	-8.420E-01
28	1.60	5.200E-02	1.495E+01	1.201E+01	-6.230E+00	9.790E+00	-8.500E-01	-8.560E-01
29	1.65	4.000E-02	1.497E+01	1.199E+01	-6.200E+00	9.830E+00	-8.100E-01	-8.300E-01
30	1.70	4.000E-02	1.497E+01	1.207E+01	-6.264E+00	9.852E+00	-8.240E-01	-8.400E-01
31	1.75	4.200E-02	1.498E+01	1.206E+01	-6.230E+00	9.836E+00	-8.140E-01	-8.460E-01
32	1.80	4.600E-02	1.497E+01	1.207E+01	-6.334E+00	9.958E+00	-8.220E-01	-8.160E-01
33	1.85	4.000E-02	1.499E+01	1.212E+01	-6.320E+00	9.920E+00	-8.100E-01	-8.040E-01
34	1.90	2.600E-02	1.500E+01	1.215E+01	-6.376E+00	1.009E+01	-8.180E-01	-8.120E-01
35	2.00	4.400E-02	1.497E+01	1.216E+01	-6.338E+00	9.996E+00	-8.180E-01	-8.400E-01
36	2.00	4.600E-02	1.495E+01	1.221E+01	-6.366E+00	9.988E+00	-8.200E-01	-8.480E-01
37	2.05	4.000E-02	1.497E+01	1.226E+01	-6.368E+00	1.004E+01	-8.180E-01	-8.420E-01
38	2.10	4.000E-02	1.496E+01	1.226E+01	-6.348E+00	9.976E+00	-8.160E-01	-8.160E-01
39	2.15	4.400E-02	1.496E+01	1.228E+01	-6.386E+00	1.005E+01	-8.120E-01	-8.320E-01
40	2.20	3.600E-02	1.496E+01	1.230E+01	-6.442E+00	1.004E+01	-7.980E-01	-8.180E-01
41	2.25	3.800E-02	1.495E+01	1.230E+01	-6.458E+00	9.982E+00	-8.300E-01	-8.220E-01
42	2.35	3.000E-02	1.497E+01	1.238E+01	-6.432E+00	9.952E+00	-8.280E-01	-8.340E-01
43	2.45	4.800E-02	1.494E+01	1.239E+01	-6.456E+00	9.812E+00	-8.360E-01	-8.600E-01
44	2.55	3.800E-02	1.495E+01	1.240E+01	-6.512E+00	9.568E+00	-8.300E-01	-8.360E-01
45	2.65	2.800E-02	1.496E+01	1.246E+01	-6.480E+00	9.304E+00	-8.120E-01	-8.160E-01
46	2.75	3.600E-02	1.496E+01	1.246E+01	-6.508E+00	8.848E+00	-8.500E-01	-8.740E-01
47	2.85	4.000E-02	1.493E+01	1.248E+01	-6.506E+00	8.528E+00	-8.600E-01	-8.280E-01
48	2.95	2.800E-02	1.495E+01	1.254E+01	-6.528E+00	7.950E+00	-8.160E-01	-8.280E-01

TABLE B4 (CONT.). DOWNSTREAM BLADE-TO-BLADE SCALED PROBE DATA FILE U-4SEPASCL

SCAN	8	9	10	11	12	13	14	YAW DEG	TEMP (R)	ATMOS PRESS
1	-3.500E-01	-1.026E+00	9.332E+00	-8.200E+00	0.000E+00	-8.000E-03	0.000E+00	2.007E+00	4.557E+02	405.20
2	-3.100E-01	-9.600E-01	9.310E+00	-8.170E+00	-1.200E-02	1.000E-02	8.000E-03	2.010E+00	4.556E+02	405.20
3	-3.040E-01	-9.700E-01	9.282E+00	-8.166E+00	-1.000E-02	-8.000E-03	-1.000E-02	2.007E+00	4.555E+02	405.20
4	-3.400E-01	-9.240E-01	9.270E+00	-8.170E+00	4.000E-03	8.000E-03	1.400E-02	1.763E+00	4.556E+02	405.20
5	-3.240E-01	-9.920E-01	9.230E+00	-8.184E+00	-1.000E-02	2.000E-03	-2.000E-03	1.757E+00	4.556E+02	405.20
6	-3.140E-01	-9.900E-01	9.210E+00	-8.154E+00	-1.200E-02	-8.000E-03	-3.000E-02	2.004E+00	4.556E+02	405.20
7	-3.060E-01	-9.020E-01	9.230E+00	-8.170E+00	-1.200E-02	-1.000E-02	-1.000E-02	2.264E+00	4.556E+02	405.20
8	-3.360E-01	-9.900E-01	9.236E+00	-8.124E+00	0.000E+00	8.000E-03	-1.000E-02	2.258E+00	4.555E+02	405.20
9	-3.520E-01	-9.100E-01	9.282E+00	-8.136E+00	-1.200E-02	-2.000E-02	-2.200E-02	2.531E+00	4.556E+02	405.20
10	-3.500E-01	-9.540E-01	9.100E+00	-8.106E+00	-1.000E-02	-4.000E-03	0.000E+00	2.624E+00	4.556E+02	405.20
11	-3.040E-01	-9.420E-01	9.240E+00	-8.116E+00	-1.000E-02	2.000E-03	4.000E-03	2.708E+00	4.556E+02	405.20
12	-3.020E-01	-9.020E-01	9.254E+00	-8.168E+00	-1.000E-02	-1.400E-02	-8.000E-03	2.700E+00	4.557E+02	405.20
13	-4.040E-01	-1.036E+00	9.554E+00	-8.310E+00	-8.000E-03	-1.000E-02	-1.400E-02	3.026E+00	4.557E+02	405.20
14	-4.260E-01	-1.074E+00	9.692E+00	-8.442E+00	-1.200E-02	-6.000E-03	-2.000E-03	3.296E+00	4.557E+02	405.20
15	-4.360E-01	-1.108E+00	9.792E+00	-8.520E+00	-8.000E-03	-4.000E-03	-8.000E-03	3.275E+00	4.557E+02	405.20
16	-4.400E-01	-1.170E+00	9.952E+00	-8.600E+00	-4.000E-03	4.000E-03	-8.000E-03	3.554E+00	4.558E+02	405.20
17	-4.260E-01	-1.110E+00	9.954E+00	-8.640E+00	-1.400E-02	8.000E-03	2.000E-03	3.550E+00	4.558E+02	405.20
18	-4.320E-01	-1.162E+00	1.007E+01	-8.714E+00	-6.000E-03	-2.000E-03	-8.000E-03	3.540E+00	4.558E+02	405.20
19	-4.460E-01	-1.202E+00	1.013E+01	-8.722E+00	-2.000E-02	-1.400E-02	-1.200E-02	3.556E+00	4.557E+02	405.20
20	-4.460E-01	-1.184E+00	1.018E+01	-8.684E+00	-1.400E-02	-4.000E-03	2.000E-03	3.294E+00	4.558E+02	405.20
21	-4.360E-01	-1.328E+00	1.022E+01	-8.802E+00	6.000E-03	4.000E-03	-4.000E-03	3.281E+00	4.557E+02	405.20
22	-4.100E-01	-1.214E+00	1.026E+01	-8.732E+00	2.000E-03	4.000E-03	-8.000E-03	3.284E+00	4.558E+02	405.20
23	-3.940E-01	-1.226E+00	1.027E+01	-8.784E+00	-2.200E-02	-8.000E-03	-4.000E-03	3.296E+00	4.558E+02	405.20
24	-3.920E-01	-1.174E+00	1.022E+01	-8.772E+00	-2.400E-02	-1.600E-02	-1.200E-02	3.285E+00	4.559E+02	405.20
25	-3.700E-01	-1.178E+00	1.027E+01	-8.820E+00	-1.000E-02	-2.000E-03	6.000E-03	3.296E+00	4.559E+02	405.20
26	-3.580E-01	-1.180E+00	1.031E+01	-8.860E+00	-1.000E-02	-1.600E-02	-1.200E-02	3.023E+00	4.559E+02	405.20
27	-3.480E-01	-1.104E+00	1.035E+01	-8.826E+00	-4.000E-03	-8.000E-03	0.000E+00	3.039E+00	4.559E+02	405.20
28	-3.340E-01	-1.210E+00	1.034E+01	-8.830E+00	-6.000E-03	-1.200E-02	-1.200E-02	3.041E+00	4.558E+02	405.20
29	-3.300E-01	-1.202E+00	1.037E+01	-8.954E+00	-8.000E-03	-1.200E-02	-8.000E-03	3.024E+00	4.560E+02	405.20
30	-5.950E-01	-1.378E+00	1.039E+01	-8.892E+00	-2.200E-02	-6.000E-03	-8.000E-03	3.036E+00	4.559E+02	405.20
31	-2.040E-01	-1.552E+00	1.036E+01	-8.910E+00	-2.400E-02	-1.200E-02	-1.200E-02	3.036E+00	4.558E+02	405.20
32	-3.740E-01	-1.306E+00	1.040E+01	-8.976E+00	4.000E-03	-4.000E-03	-1.600E-02	2.776E+00	4.558E+02	405.20
33	-2.940E-01	-1.210E+00	1.043E+01	-7.012E+00	2.000E-03	-2.000E-03	0.000E+00	2.772E+00	4.558E+02	405.20
34	-1.040E-01	-1.544E+00	1.044E+01	-8.942E+00	1.000E-02	1.400E-02	0.000E+00	2.782E+00	4.558E+02	405.20
35	-1.600E-01	-1.566E+00	1.048E+01	-8.990E+00	-1.000E-02	-1.400E-02	-1.200E-02	2.778E+00	4.559E+02	405.20
36	-1.060E-01	-1.584E+00	1.047E+01	-7.040E+00	-1.000E-02	-3.200E-02	-8.000E-03	2.773E+00	4.561E+02	405.20
37	-3.560E-02	-1.378E+00	1.052E+01	-7.044E+00	2.000E-03	-1.400E-02	-3.200E-02	2.781E+00	4.562E+02	405.20
38	-4.160E-01	-1.406E+00	1.053E+01	-7.052E+00	6.939E-18	-4.000E-03	2.000E-03	2.787E+00	4.562E+02	405.20
39	-2.700E-01	-1.262E+00	1.054E+01	-7.060E+00	-1.600E-02	-1.200E-02	-1.000E-02	2.771E+00	4.561E+02	405.20
40	-3.450E-01	-1.390E+00	1.060E+01	-7.060E+00	8.000E-03	-6.000E-03	-8.000E-03	2.784E+00	4.560E+02	405.20
41	-2.540E-01	-1.248E+00	1.062E+01	-7.080E+00	4.000E-03	-2.000E-03	-4.000E-03	2.536E+00	4.561E+02	405.20
42	-9.200E-02	-1.602E+00	1.064E+01	-7.100E+00	-8.000E-03	-4.000E-03	-4.000E-03	2.527E+00	4.561E+02	405.20
43	-1.220E-01	-1.642E+00	1.066E+01	-7.122E+00	-1.400E-02	-1.400E-02	-1.600E-02	2.537E+00	4.560E+02	405.20
44	-5.300E-01	-1.472E+00	1.068E+01	-7.150E+00	-1.000E-02	-4.000E-03	-2.000E-03	2.257E+00	4.561E+02	405.20
45	-2.620E-01	-1.396E+00	1.069E+01	-7.186E+00	-4.000E-03	-2.000E-03	-4.000E-03	2.270E+00	4.560E+02	405.20
46	-3.340E-01	-1.400E+00	1.075E+01	-7.208E+00	-4.000E-03	-6.000E-03	-1.400E-02	2.023E+00	4.561E+02	405.20
47	-3.240E-01	-1.294E+00	1.071E+01	-7.164E+00	-4.000E-03	-8.000E-03	-4.000E-03	1.751E+00	4.561E+02	405.20
48	-3.300E-01	-1.270E+00	1.070E+01	-7.190E+00	1.000E-02	-2.000E-03	-8.000E-03	1.768E+00	4.561E+02	405.20

TABLE B5. DOWNSTREAM BLADE-TO-BLADE REDUCED PROBE DATA FILE U-4SEPACALC

SCAN	Vel	Vref	Q	Qref	MACH	YAW DEG
1	1.673E+02	2.032E+02	7.277E+00	1.078E+01	1.603E-01	2.007E+00
2	1.640E+02	2.026E+02	6.992E+00	1.071E+01	1.571E-01	2.010E+00
3	1.560E+02	2.019E+02	6.332E+00	1.064E+01	1.495E-01	2.007E+00
4	1.504E+02	2.019E+02	5.880E+00	1.064E+01	1.440E-01	1.763E+00
5	1.446E+02	2.017E+02	5.434E+00	1.062E+01	1.385E-01	1.757E+00
6	1.409E+02	2.017E+02	5.157E+00	1.062E+01	1.349E-01	2.004E+00
7	1.405E+02	2.016E+02	5.130E+00	1.061E+01	1.346E-01	2.264E+00
8	1.403E+02	2.015E+02	5.112E+00	1.060E+01	1.343E-01	2.258E+00
9	1.406E+02	2.013E+02	5.135E+00	1.058E+01	1.346E-01	2.531E+00
10	1.423E+02	2.014E+02	5.260E+00	1.059E+01	1.363E-01	2.624E+00
11	1.440E+02	2.017E+02	5.384E+00	1.062E+01	1.379E-01	2.788E+00
12	1.468E+02	2.018E+02	5.598E+00	1.063E+01	1.406E-01	2.780E+00
13	1.516E+02	2.048E+02	5.974E+00	1.095E+01	1.452E-01	3.026E+00
14	1.564E+02	2.068E+02	6.359E+00	1.117E+01	1.498E-01	3.296E+00
15	1.613E+02	2.077E+02	6.759E+00	1.127E+01	1.545E-01	3.275E+00
16	1.656E+02	2.094E+02	7.125E+00	1.144E+01	1.586E-01	3.554E+00
17	1.700E+02	2.100E+02	7.511E+00	1.151E+01	1.628E-01	3.550E+00
18	1.747E+02	2.106E+02	7.939E+00	1.158E+01	1.674E-01	3.540E+00
19	1.780E+02	2.110E+02	8.245E+00	1.162E+01	1.706E-01	3.556E+00
20	1.818E+02	2.115E+02	8.601E+00	1.168E+01	1.742E-01	3.294E+00
21	1.850E+02	2.121E+02	8.911E+00	1.175E+01	1.773E-01	3.281E+00
22	1.875E+02	2.123E+02	9.155E+00	1.177E+01	1.797E-01	3.284E+00
23	1.903E+02	2.125E+02	9.435E+00	1.179E+01	1.825E-01	3.296E+00
24	1.913E+02	2.120E+02	9.528E+00	1.174E+01	1.834E-01	3.285E+00
25	1.932E+02	2.125E+02	9.721E+00	1.179E+01	1.852E-01	3.296E+00
26	1.945E+02	2.125E+02	9.855E+00	1.178E+01	1.865E-01	3.023E+00
27	1.954E+02	2.130E+02	9.953E+00	1.185E+01	1.874E-01	3.039E+00
28	1.959E+02	2.134E+02	9.998E+00	1.189E+01	1.878E-01	3.041E+00
29	1.960E+02	2.132E+02	1.000E+01	1.187E+01	1.879E-01	3.024E+00
30	1.963E+02	2.139E+02	1.004E+01	1.195E+01	1.882E-01	3.036E+00
31	1.961E+02	2.138E+02	1.002E+01	1.194E+01	1.880E-01	3.036E+00
32	1.970E+02	2.139E+02	1.012E+01	1.195E+01	1.889E-01	2.776E+00
33	1.966E+02	2.143E+02	1.007E+01	1.199E+01	1.885E-01	2.772E+00
34	1.981E+02	2.146E+02	1.023E+01	1.203E+01	1.900E-01	2.782E+00
35	1.975E+02	2.147E+02	1.016E+01	1.203E+01	1.893E-01	2.778E+00
36	1.975E+02	2.151E+02	1.016E+01	1.208E+01	1.893E-01	2.773E+00
37	1.979E+02	2.156E+02	1.020E+01	1.213E+01	1.897E-01	2.781E+00
38	1.973E+02	2.156E+02	1.013E+01	1.213E+01	1.891E-01	2.787E+00
39	1.979E+02	2.158E+02	1.020E+01	1.215E+01	1.897E-01	2.771E+00
40	1.977E+02	2.159E+02	1.019E+01	1.217E+01	1.896E-01	2.784E+00
41	1.974E+02	2.159E+02	1.015E+01	1.217E+01	1.892E-01	2.536E+00
42	1.971E+02	2.166E+02	1.012E+01	1.225E+01	1.890E-01	2.527E+00
43	1.960E+02	2.166E+02	1.001E+01	1.225E+01	1.880E-01	2.537E+00
44	1.938E+02	2.167E+02	9.778E+00	1.226E+01	1.857E-01	2.257E+00
45	1.912E+02	2.173E+02	9.520E+00	1.232E+01	1.833E-01	2.270E+00
46	1.875E+02	2.173E+02	9.151E+00	1.233E+01	1.797E-01	2.023E+00
47	1.844E+02	2.175E+02	8.846E+00	1.235E+01	1.767E-01	1.751E+00
48	1.787E+02	2.180E+02	8.302E+00	1.240E+01	1.712E-01	1.768E+00
49	1.762E+02	2.181E+02	8.075E+00	1.242E+01	1.688E-01	1.770E+00

TABLE B5 (CONT.). DOWNSTREAM BLADE-TO-BLADE REDUCED PROBE DATA FILE U-4SEPACALC

SCAN	PRB POSIT	BETA	GAMMA	PHI	Xvel	Xref
1	0.00	1.853E-02	8.853E-02	-4.111E-03	7.148E-02	8.684E-02
2	.10	1.779E-02	8.983E-02	-4.764E-03	7.008E-02	8.658E-02
3	.20	1.610E-02	1.018E-01	-1.102E-02	6.671E-02	8.630E-02
4	.30	1.493E-02	9.524E-02	-7.663E-03	6.429E-02	8.628E-02
5	.40	1.381E-02	1.002E-01	-1.043E-02	6.181E-02	8.621E-02
6	.50	1.313E-02	1.070E-01	-1.413E-02	6.022E-02	8.620E-02
7	.55	1.304E-02	9.654E-02	-8.619E-03	6.007E-02	8.617E-02
8	.60	1.301E-02	1.054E-01	-1.327E-02	5.996E-02	8.613E-02
9	.65	1.307E-02	1.042E-01	-1.263E-02	6.010E-02	8.605E-02
10	.70	1.336E-02	9.202E-02	-6.184E-03	6.082E-02	8.610E-02
11	.75	1.369E-02	1.029E-01	-1.186E-02	6.153E-02	8.622E-02
12	.80	1.423E-02	1.027E-01	-1.167E-02	6.274E-02	8.624E-02
13	.85	1.519E-02	1.013E-01	-1.083E-02	6.480E-02	8.752E-02
14	.90	1.617E-02	9.750E-02	-8.767E-03	6.686E-02	8.838E-02
15	.95	1.719E-02	9.498E-02	-7.432E-03	6.892E-02	8.878E-02
16	1.00	1.815E-02	9.660E-02	-8.275E-03	7.075E-02	8.947E-02
17	1.05	1.914E-02	8.667E-02	-3.176E-03	7.263E-02	8.973E-02
18	1.10	2.027E-02	8.728E-02	-3.539E-03	7.466E-02	8.999E-02
19	1.15	2.107E-02	8.687E-02	-3.363E-03	7.607E-02	9.017E-02
20	1.20	2.200E-02	7.894E-02	6.477E-04	7.768E-02	9.036E-02
21	1.25	2.282E-02	9.446E-02	-7.283E-03	7.906E-02	9.065E-02
22	1.30	2.346E-02	8.278E-02	-1.351E-03	8.013E-02	9.074E-02
23	1.35	2.419E-02	8.302E-02	-1.469E-03	8.133E-02	9.080E-02
24	1.40	2.443E-02	7.724E-02	1.466E-03	8.173E-02	9.059E-02
25	1.45	2.493E-02	7.817E-02	1.007E-03	8.254E-02	9.081E-02
26	1.50	2.528E-02	7.916E-02	5.131E-04	8.310E-02	9.077E-02
27	1.55	2.553E-02	7.892E-02	6.459E-04	8.351E-02	9.103E-02
28	1.60	2.565E-02	8.306E-02	-1.447E-03	8.370E-02	9.118E-02
29	1.65	2.566E-02	8.188E-02	-8.475E-04	8.372E-02	9.110E-02
30	1.70	2.574E-02	7.319E-02	3.562E-03	8.386E-02	9.140E-02
31	1.75	2.570E-02	1.264E-01	-2.334E-02	8.378E-02	9.136E-02
32	1.80	2.596E-02	9.390E-02	-6.922E-03	8.420E-02	9.139E-02
33	1.85	2.584E-02	8.539E-02	-2.619E-03	8.401E-02	9.156E-02
34	1.90	2.625E-02	1.247E-01	-2.247E-02	8.467E-02	9.170E-02
35	1.95	2.607E-02	1.291E-01	-2.471E-02	8.438E-02	9.172E-02
36	2.00	2.607E-02	1.292E-01	-2.473E-02	8.437E-02	9.189E-02
37	2.05	2.617E-02	9.404E-02	-6.975E-03	8.454E-02	9.208E-02
38	2.10	2.599E-02	9.173E-02	-5.821E-03	8.426E-02	9.209E-02
39	2.15	2.618E-02	9.126E-02	-5.569E-03	8.455E-02	9.218E-02
40	2.20	2.613E-02	9.622E-02	-8.083E-03	8.447E-02	9.224E-02
41	2.25	2.603E-02	9.197E-02	-5.938E-03	8.432E-02	9.222E-02
42	2.35	2.597E-02	1.400E-01	-3.020E-02	8.422E-02	9.252E-02
43	2.45	2.569E-02	1.426E-01	-3.151E-02	8.376E-02	9.255E-02
44	2.55	2.508E-02	9.057E-02	-5.278E-03	8.278E-02	9.259E-02
45	2.65	2.441E-02	1.121E-01	-1.619E-02	8.169E-02	9.282E-02
46	2.75	2.345E-02	1.098E-01	-1.506E-02	8.010E-02	9.282E-02
47	2.85	2.265E-02	1.035E-01	-1.188E-02	7.877E-02	9.290E-02
48	2.95	2.123E-02	1.072E-01	-1.374E-02	7.633E-02	9.311E-02
49	3.00	2.064E-02	1.105E-01	-1.547E-02	7.528E-02	9.319E-02

TABLE B5 (CONT.). DOWNSTREAM BLADE-TO-BLADE REDUCED PROBE DATA FILE U-4SEPACALC

SCAN	Pref-Pt/Qref
1	3.650E-01
2	3.889E-01
3	4.490E-01
4	4.[illegible]9E-01
5	5.331E-01
6	5.584E-01
7	5.628E-01
8	5.633E-01
9	5.632E-01
10	5.527E-01
11	5.417E-01
12	5.238E-01
13	5.062E-01
14	4.834E-01
15	4.529E-01
16	4.282E-01
17	3.963E-01
18	3.631E-01
19	3.374E-01
20	3.068E-01
21	2.827E-01
22	2.606E-01
23	2.361E-01
24	2.232E-01
25	2.076E-01
26	1.937E-01
27	1.879E-01
28	1.871E-01
29	1.822E-01
30	1.860E-01
31	1.865E-01
32	1.770E-01
33	1.833E-01
34	1.718E-01
35	1.799E-01
36	1.837E-01
37	1.831E-01
38	1.883E-01
39	1.840E-01
40	1.856E-01
41	1.902E-01
42	1.981E-01
43	2.101E-01
44	2.306E-01
45	2.559E-01
46	2.931E-01
47	3.201E-01
48	3.700E-01
49	3.912E-01

****

ENSEMBLE AVERAGES

PPAVG	PAAVG	TEMPAVG	XREFAVG	VREFAVG	QREFAVG
1.172E+01	405.20E+00	455.84	9.007E-02	2.108E+02	1.160E+01

TABLE B6. BLADE SCALED DATA FILE B-4SEPASCL

PROBE DATA ASSOCIATED WITH THE BLADE DATA IS CONTAINED
IN FILE: L-4SEPASCL
SCAN: 31

SCANIVALVE PORT	PRESS (INCHES H_2O)
1	8.000E-03
2	1.487E+01
3	1.284E+01
4	-3.614E+00
5	-1.134E+00
6	2.300E-01
7	8.600E-01
8	9.520E-01
9	9.200E-01
10	6.640E-01
11	9.020E-01
12	6.600E-01
13	1.002E+00
14	1.846E+00
15	2.428E+00
16	2.182E+00
17	1.482E+00
18	1.812E+00
19	2.396E+00
20	4.026E+00
21	4.906E+00
22	7.336E+00
23	-1.924E+01
24	-3.496E+01
25	-3.382E+01
26	-2.966E+01
27	-2.221E+01
28	-1.806E+01
29	-1.496E+01
30	-1.304E+01
31	-1.105E+01
32	-8.656E+00
33	-7.204E+00
34	-5.974E+00
35	-5.214E+00
36	-4.570E+00
37	-4.060E+00
38	-3.906E+00
39	-3.716E+00
40	-3.502E+00
41	-3.254E+00
42	-3.156E+00
43	-7.160E-01
44	-9.750E+00
45	-3.586E+00
46	1.612E+00
47	9.860E-01
48	-2.896E+00

TABLE B7. BLADE REDUCED DATA FILE B-4SEPACALC

SCANIVALVE PORT	MASS AVERAGED COEFFICIENT OF PRESSURE
4	2.133E-01
5	3.507E-01
6	4.263E-01
7	4.612E-01
8	4.663E-01
9	4.646E-01
10	4.515E-01
11	4.636E-01
12	4.513E-01
13	4.691E-01
14	5.160E-01
15	5.481E-01
16	5.345E-01
17	4.957E-01
18	5.140E-01
19	5.463E-01
20	6.367E-01
21	6.854E-01
22	8.201E-01
23	-6.524E-01
24	-1.525E+00
25	-1.460E+00
26	-1.230E+00
27	-8.171E-01
28	-5.869E-01
29	-4.153E-01
30	-3.092E-01
31	-1.986E-01
32	-6.606E-02
33	1.440E-02
34	8.255E-02
35	1.247E-01
36	1.604E-01
37	1.886E-01
38	1.971E-01
39	2.077E-01
40	2.195E-01
41	2.333E-01
42	2.386E-01
43	3.739E-01
44	-1.267E-01
45	2.149E-01
46	5.029E-01
47	4.682E-01
48	2.531E-01

2. RETURN

3. Press LOAD

4. Type INITFLEX between quotation marks. [The root directory based INITFLEX program formats the disc.]

5. RETURN

6. Press RUN

7. Follow the prompts--the process takes a few minutes.

Once the disc is formatted, it can be used to back up files. To load the root directory-based BACKUP program, use the following steps:

1. Type MSI"/"

2. RETURN

3. Press LOAD

4. Type BACKUP between quotation marks

5. RETURN

6. Press RUN

7. Press SELECT. [The arrow indicator will be at the desired position i.e., "Backup selected files."]

8. Type /CLASSICK/DESIRED SUBDIRECTORY/=:CS80,700

9. RETURN

10. Press PROCEED. [Use arrow keys to move indicator to flexible disc option.]

11. Press SELECT

12. Press YES. [Note the caution]

The backup process proceeds to completion, displaying each file transferred to the flexible disc. If there are too many files for one disc, a prompt for an additional disc

will be displayed. Note that the files generated by "CALC" consume a lot of disc space. Upon completion,

13. Press UNLDTAPE
14. Press DONE

B.9 RECOMMENDATIONS

The method of obtaining probe survey data can be improved upon by making changes to the three main programs and including software additions. Changes to the programs will provide higher quality data, reduce the chance of erroneous entries and make computations more efficient. Software additions will enhance data recovery and reduce the chance of mistakenly deleting data files. Specific recommendations are:

1. Improve the existing DVM error trap. Occasional surges in the facilitie's power supply cause spurious DVM readings. Spurious DVM readings are trapped by the Maxdif variable on line 91 of "ACQUIRE" and the IF-THEN structure in the subprogram "Readdvm". The existing trap is adequate for Scanivalve port readings but not for yaw transducer readings. A separate Maxdif value, and incorporation into "Readdvm", is required for the yaw transducer. Alternately, a subroutine to statistically analyze and reject spurious DVM readings could be added to "Readdvm", [A more extensive but permanent solution is to rectify the power surge problem.]

2. Dynamically size the CALC array in program "CALC." This is done in "ACQUIRE" with the Rawdat and Scaled arrays. Dynamic sizing would reduce the amount of disc space the reduced data files from "CALC"consume.

3. Eliminate the need in "ACQUIRE" for scan number and position entries by the user for each data point. For repetitive surveys with a known number of data points and probe displacement interval, a data file could be used to supply those values.

4. Combine "CALC" and "LOSS." The AVDR and loss coefficient could be calculated within the structure that calculates C_p. While this would eliminate one program, it would complicate the structure of "CALC" somewhat and make the structure more difficult for a new user to grasp.

5. Create a subdirectory for the scaled data files from "ACQUIRE." This would eliminate the clutter of files in the REDDATA subdirectory, and make the file system consistent with the distinction that program "CALC" makes between scaled and reduced data files. A cluttered file system increases the chances of losing a valuable file during a purge. This addition would require change to the MSI statements on lines 130, 374, 581 and 763 in "ACQUIRE" and line 130 in "CALC." A MSI "/CLASSICK/REDDATA" would have to be inserted before

line 134 to allow access to the probe coefficients file stored in the subdirectory READDATA.

6. Develop a program to print a tabulation of the data stored in the scaled data files. This tabulation should duplicate the format in "ACQUIRE." The program can be produced by appropriate additions and deletions to "ACQUIRE" since the formatted print statements already exist. [See Chapter 11, Ref. 13.]

B10. FOR THE USER - SUMMARY OF PROGRAM STEPS

All commands except RETURN are executed by pressing the set of keys f1 - f8 corresponding to the soft key labels appearing at the bottom of the screen. RETURN is the key found on the main keyboard.

The following is a summary of program steps:

1. DVM, Scanner and Scanivalve Controller--ON
2. Disc Drive--ON
3. Disc Drive Amber Lights--EXTINGUISHED
4. Computer, Monitor and Printer--ON
5. LOAD "/CLASSICK/PROGS/ACQUIRE"
6. RETURN
7. RUN
8. Type raw data file name for probe survey without quotation marks.
9. RETURN
10. Type scaled data file name for probe survey.
11. RETURN

12. Type atmospheric pressure in inches Hg.

13. RETURN

14. Press ONE PROBE or TWO PROBES

15. Type scan number and probe position. For two probe option, type scan number, lower probe position and upper probe position.

16. RETURN

17. Press REPEAT or RECORD

[REPEAT returns prompt for scan number and position of data point to be repeated. Record stores data to the file.]

18. Press GO ON or END PRB DATA

[GO ON, returns prompt for scan number and probe position of next data point. END PRB DATA terminates probe data collection.]

19. Press GO ON or COLLECT

[GO ON, by-passes blade data collection and returns print option prompts (Step 20). COLLECT, returns prompt for raw blade data file name.]

a. Type raw blade data file name

b. RETURN

c. Type scaled blade data file name

d. RETURN

e. Press REPEAT or RECORD

[REPEAT, repeats the blade pressure scan RECORD, stores data to the file.]

20. Follow the print option prompts

Note that this is the only time to obtain a hard copy of the raw and scaled probe and blade data.

21. Press GO ON or CALC

[GO ON, Terminates "ACQUIRE"]

Note that "CALC" can be executed later by the command: LOAD "/CLASSICK/PROGS/CALC" CALC, Loads and executes "CALC")

22. Type the scaled probe data file name created in "ACQUIRE."

23. RETURN

24. Type the probe calibration coefficient file for X (velocity).

25. RETURN

26. Type the probe calibration coefficient file for Phi (pitch).

27. RETURN

28. Press ONE PROBE or TWO PROBES

(TWO PROBES, will prompt the user for the upper probe calibration coefficient files for X and Phi)

29. Type the file name for the data to be reduced from the scaled data file. For two probes, a second scaled data file name is required.

30. RETURN

31. Press REDUCE DATA after amber light quits blinking.

32. Press GO ON or BLADE Cp's.

(GO ON, returns prompt to load "LOSS" (step 33) BLADE Cp's, prompts for scaled blade data file name.)

a. Type blade scaled data file name

b. RETURN

c. Type the file name for the data to be reduced from the scaled data file.

d. RETURN

e. Type scan number associated with lower limit of integration of probe lower blade-to-blade survey.

f. RETURN

g. Type scan number associated with higher limit of integration of probe lower blade-to-blade survey.

h. RETURN

i. Press BLADE DATA after amber light quits blinking.

33. Press GO ON or LOSS

a. GO ON terminates "CALC". Note that "LOSS" can can be executed later by the command:

1. LOAD "/CLASSICK/PROGS/LOSS"

2. LOSS, loads and executes "LOSS"

b. Note that "LOSS" requires upper and lower probe blade-to-blade survey reduced data file names.]

34. Type the lower probe blade-to-blade survey reduced data file name.

35. RETURN

36. Type the upper probe blade-to-blade survey reduced data file name.

37. RETURN

38. Type the scan number corresponding to the lower limit of integration for the lower probe survey.

39. RETURN

40. Type the scan number corresponding to the higher limit of integration for the lower probe survey.

41. RETURN

42. Repeat for upper probe survey.

[Note that integration interval for both upper and lower probes must be exactly equal even though the scan number entries may not be the same.]

43. Program "LOSS" terminates after static pressure rise coefficient, AVDR and loss coefficient are printed to the screen.

APPENDIX C

PROBE YAW ANGLE REFERENCING

Two methods can be used to relate yaw angle measured using the angle vernier (or electrical equivalent), to the locus of the leading edges of the cascade. Both make use of a digital precision inclinometer which measures angles to the horizontal with a resolution of 0.1°. A flat bar must be attached firmly to the probe shaft.

C.1 FREE-JET METHOD

Step 1 Mount the probe in the free-jet from the N side as shown in Figure C1(a).

Balance the probe pneumatically.

Read the angle of the bar (to horizontal) using the inclinometer (Δ_1).

Step 2 Mount the probe in the free-jet from the S side as shown in Figure C1(b).

Balance the probe pneumatically.

Read the angle of the bar (to horizontal) using the inclinometer (Δ_2).

Step 3 If Δ_0 is the angle of the probe pneumatic axis (P.A.) to the surface of the bar, and δ_J is the inclination of the free-jet to the horizontal, then

$$\Delta_1 = \Delta_0 - \delta_J$$

and

$$\Delta_2 = \Delta_0 + \delta_J.$$

Hence

$$\Delta_0 = \left(\frac{\Delta_1 + \Delta_2}{2} \right)$$

$$\delta_J = \left(\frac{\Delta_1 - \Delta_2}{2} \right)$$

Step 4 Mount the probe on the cascade on the N side as shown in Figure C1(c).

Read the vernier when the bar is horizontal (β_H).

Then, the angle of the pneumatic axis to the vertical

$$\beta_{PA} = 90 - \Delta_O \ .$$

Angle of the pneumatic axis to the normal to the locus of the leading edges

$$\beta'_{PA} = \beta_{PA} - \delta_B = 90 - \Delta_O - \delta_B \ .$$

Rotate probe to balance in the flow. Read the venier (β_F).

The flow angle, related correctly to the normal to the locus of the leading edges, is given by

$$\begin{aligned} \beta &= \beta'_{PA} + (\beta_F - \beta_H) \\ &= 90° - \Delta_O - \delta_B + (\beta_F - \beta_H) \end{aligned}$$

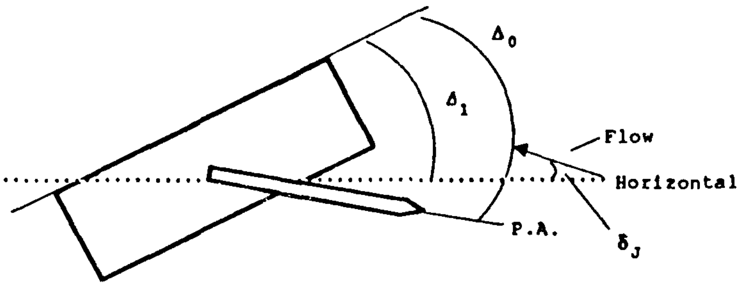
C.2 LDV (IN SITU) METHOD

Mount the probe and balance at a point where β_1 is known from LDV measurements. Read the vernier (β_{F_1}). Turn the bar to horizontal. Read the vernier (β_H)

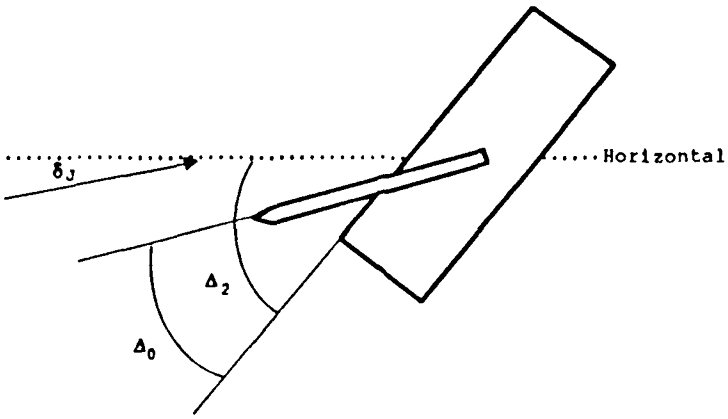
then $\quad \beta'_{PA} = \beta_1 - (\beta_{F_1} - \beta_H) = (\beta_1 - \beta_{F_1}) + \beta_H$

At any other condition, the inlet air angle is given by

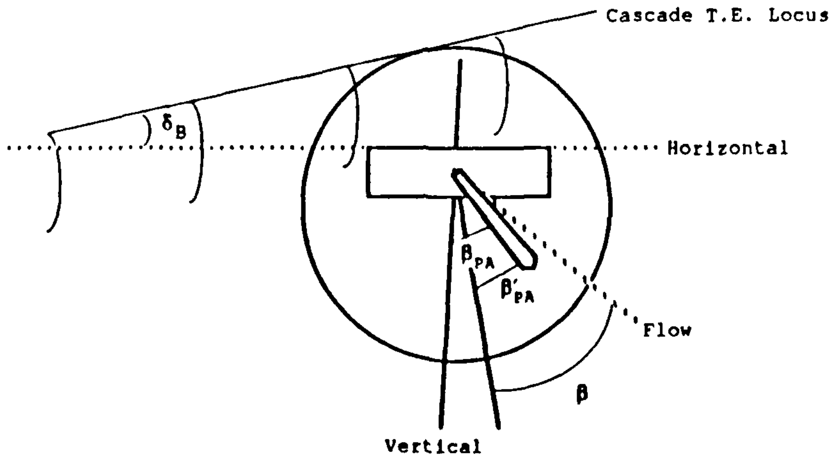
$$\begin{aligned} \beta &= \beta'_{PA} + (\beta_F - \beta_H) \\ &= (\beta_1 - \beta_{F_1}) + \beta_F. \end{aligned}$$



a) From N. Side on Free-Jet



b) From S. Side on Free-Jet



c) From N. Side on Cascade

Figure C1. Probe Angle Referencing

LIST OF REFERENCES

1. NASA Report SP-36, Aerodynamic Design of Axial-Flow Compressors, edited by Irving A. Johnson and Robert A. Bullock, 1965.

2. NASA Technical Memorandum 82763, The Use of Optimization Techniques to Design Compressor Blading, by Nelson L. Sanger, Lewis Research Center, Cleveland, Ohio, 1982.

3. Koyuncu, Y., Report of Tests of a Compressor Configuration of CD Blading, M.S. Thesis, Naval Postgraduate School, Monterey, California, March 1984.

4. Dreon, J., Controlled Diffusion Compressor Blade Wake Measurements, M.S. Thesis, Naval Postgraduate School, Monterey, California, September 1986.

5. Elazar, Y., A Mapping of the Flow Behavior in a Controlled Diffusion Compressor Cascade Using Laser Doppler Velocimetry and Preliminary Evaluation of Codes for the Prediction of Stall, Ph.D Dissertation, Naval Postgraduate School, Monterey, California, March 1988.

6. Baydar, A., Hot-Wire Measurements of Compressor Blade Wakes in a Cascade Wind Tunnel, M.S., Thesis, Naval Postgraduate School, Monterey, California, March 1988.

7. NACA Report 1016, Effect of Tunnel Configuration and Testing Technique on Cascade Performance, by John R. Erwin and James C. Emery, 1951.

8. DuVal, D.A., Evaluation of a Subsonic Cascade Wind Tunnel for Compressor Blade Testing, M.S. Thesis, Naval Postgraduate School, Monterey, California, September 1980.

9. Sanger, N.L., and Shreeve, R.P., "Comparison of Calculated and Experimental Cascade Performance for Controlled-Diffusion Compressor Stator Blading," Journal of Turbomachinery, Volume 108, Number 1, July 1986, pp. 42-50.

10. Geopfarth, R., Development of a Device for the Incorporation of Multiple Scanivalves into a Computer-Controlled Data System, M.S. Thesis, Naval Postgraduate School, Monterey, California, March 1979.

11. Murray, K., Automation and Extension of LDV Measurements of Off-Design Flow in a Subsonic Cascade Wind Tunnel, A.E. Thesis, Naval Postgraduate School, Monterey, California, June 1989.

12. Naval Postgraduate School Contract Report NPS 67-81-03CR, Calibration and Application of a Combination Temperature-Pneumatic Probe for Velocity and Rotor Loss Distribution Measurements in a Compressor, by F. Neuhoff, 1981.

13. User's Manual, Installing, Using, and Maintaining the BASIC 5.0 System, Hewlett Packard, 1987.

14. User's Manual, Basic 5.0 Programming Techniques, Volume 1: General Topics, Hewlett Packard, 1987.

15. User's Manual, BASIC 5.0 Language Reference A-L, Hewlett Packard, 1987.

16. User's Manual, BASIC 5.0 Language Reference M-Z, Hewlett Packard, 1987.

17. User's Manual, BASIC 5.0 Graphics Techniques, Hewlett Packard, 1987.

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